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History of the Steam Engine, with a reply to the Criticisms to which the first publication of the article gave rise. By M. Arago.

[From the Annual of the Board of Longitude, for 1836.]

Translated by Lieut. A. A. Harwood, U. S. N.

[continued from page 87.]

Safety Valve.

The fire placed under the boilers of large engines, is never regulated with sufficient uniformity to prevent the steam, which they contain, from acquiring, now and then, a higher degree of elasticity than that which they are capable of resisting. To prevent this inconvenience and the dangerous explosions which would ensue from it, is the object of a little apparatus which is very appropriately named *a safety valve.*

The safety valve was invented by Papin. It formed an essential part of his digester, and may be found described in pages 6, 7, 8, 9, and 10 of a small book, printed in Paris, in 1682, entitled "*La Manière d'amollir les os, etc. etc.*"* Papin's contrivance is precisely identical with the safety valves most commonly used in our time. His principle, moreover, is very simple.

* The following paragraph will be found in Robison's history of the steam engine, with notes by Watt, p. 48. "Dr. Papin, a Frenchman, invented about that time (about 1699,) a method of dissolving bones and other solid animal matter in water, by enclosing them in perfectly tight vessels, which he called digesters. These matters acquire, in this way, a great degree of heat. I ought here to observe that Hooke, the most acute experimenter of an age so fruitful in ingenious research, *had discovered* A LONG TIME BEFORE, *that is to say, in* 1684, that water, when heated in the open air could not exceed a certain degree of temperature, and that as soon as it began to boil

The object is to avoid subjecting the boiler to too violent pressure from within. To effect this, a very small portion of its side is cut out circularly, and the hole which is thus made is covered with a neatly fitted plate, movable from within outwards, just as if the corresponding portion of the boiler were movable itself. Suppose, for instance, the hole to have a surface of a square inch. Papin calculated then to how great a pressure a square inch of the boiler would be exposed, when the elasticity of the steam should have attained the prescribed limit; in this way the weight with which the valve should be loaded is determined, so that it shall not be lifted by any pressure below this limit, and that, on the contrary, it shall be raised, and give free vent to the steam whenever the limit in question is exceeded. This plan would present some difficulties if the opening of the valve being great, the pressure should require to be powerful; the weight with which it would then be necessary to load it would become considerable and difficult of adjustment; Papin, therefore, preferred working the movable plate by means of a lever. In that case a moderate weight is sufficient to counterbalance the greatest pressure. This weight suspended successively from notches made in the lever at various distances from the centre of rotation, like the weight of a steel-yard, graduates the various degrees of pressure, and enables the machinist to charge them so as to suit the kind of work in which he is employed. I have entered into details concerning Papin's safety valve, because the apparatus itself is of extreme importance, preventing, in a great measure, disastrous accidents from explosions, to which boilers were inevitably exposed before its adoption, and because it affords me a new opportunity to render our countryman a tribute of justice which has too long been withheld.*

At the time when explosions of digesters showed that a common safety valve could not be trusted, without danger, to inexperienced hands, a plan was hit upon to furnish these utensils with a piece which *must inevitably act of itself* as soon as the temperature should be too high. For this purpose an alloy was selected, known to chemists by the name of *fusible metal*, and composed of bismuth, tin, and lead. A portion of this alloy fitted in a hole made in the pot, melted, and left the aperture open, as soon as the steam acquired too great an elasticity, or, what is the same thing, too high a temperature. These fusible plates are now applied in France to all the boilers of high pressure engines, and the law requires their use. The degree of fusibility of the plates varies according to the proportion of the different metals which enter into their composition, and is always regulated before hand according to the degree of elasticity which the constructor certifies that his engine is capable of sustaining.

Hitherto I have only spoken of steam engines which have stood the test

it always marked the same degree." In order that this passage should be exact, *La Manière d'amollir les os* must have some other date than 1682; but as 1682 is actually the true date of Papin's work, Dr. Robison's *long time before* should be read, *some time afterwards*. Arguments borrowed from arithmetic are irresistible.

* Partington affirms in his interesting work that Savery's first engines were provided with a safety valve; but it is a mistake: no trace of it is found in the figure inserted in the 21st chapter of the Philosophical Transactions. Allowing it to be as stated, Papin would, nevertheless, be the true inventor, since his *patented* description is dated 1682, and Savery's patent goes no further back than 1698, and the first trial of his engine before the Royal Society took place in 1699. (Philos. Trans., vol. xxi, p. 288.)

of long experience. I had intended to devote a few pages to engines which only exist, so to speak, in theory; such as rotary engines, those to operate by hydrogen gas, and by liquified gas, etc.; but the great length which this article has already attained obliges me to postpone the notice of them. For the same reason I also suppress the detailed discussion which I had intended to give of the best shape of boilers and furnaces; the probable causes of the frequent explosions in boilers; the best effects produced by the most perfect engines known; those which future modifications may probably produce, judging by the known properties of steam. If the excursion I have made out of the region of Astronomy and Meteorology, the ordinary subjects of the notices in the *Annuaire*, does not appear out of place, I may perhaps complete this article in the next number. Meanwhile, I conclude by a succinct recapitulation of the various consequences which appear to me to flow from it.

1615. Solomon de Caus was the first to think of employing the *elastic power of Steam*, in the construction of a hydraulic draining machine.

1690. Papin conceived the possibility of making a steam engine with a piston.

1690. Papin was the first to confine, in the steam engine operating with a piston, the elastic power of steam with the property of condensation by cold.

1705. Newcomen, Cawley, and Savery were the first to perceive that to condense steam rapidly the water injected for that purpose must be forced in small drops into the very midst of the steam.

1769. Watt pointed out the great advantages in point of economy to be gained by substituting his method of condensation in a separate vessel for the method hitherto followed of effecting that operation in the cylinder itself.

1769. Watt was the first to point out the advantages to be derived from cutting off the steam in working an engine.

1690. Papin was the first to propose the employment of steam engines to turn axles or wheels, and pointed out a method for the purpose. Up to his time, steam engines had been considered as only applicable to purposes of draining.

1690. Papin proposed the first double acting engine, but with two cylinders.

1769. Watt invented the first double acting engine with a single cylinder.

Before 1710, Papin had devised the first high pressure engine, without condensation.

1724. Leupold described the first engine of this description with a piston.

1801. We are indebted to Messrs. Trevithick and Vivian for the first high pressure locomotive engine.*

1690. Papin must be considered the true inventor of steam vessels.*

In regard to the principal components of a steam engine:

1718. Beighton invented the vertical rod or *plug frame*, moved by the working beam and opening and shutting the valves in large engines.

1758. Fitzgerald was the first to make use of a fly to regulate the rotary motion communicated to an axis by the steam engine.

* The reader is requested to refer to our remarks on these heads.—Trans.

1778. Washborough employed the crank to change the rectilinear motion of the piston into one of rotation.

1784. Watt contrived the jointed parrallelogram or parallel motion.

1784. Watt applied, with great advantage, to his various engines, the centrifugal force governor, already known before his adaptation of it to this purpose.

1801. Murray described and made the first slide valves worked by an eccentric.

Before 1710, Papin had invented the four-way cock, so important in high pressure engines.

1682. Papin invented the safety valve.

An examination of the critical observations which has been made upon the preceding memoir.

The preceding *historical notice* was first published eight years ago. At that time the results which it contained differed too widely from the ideas generally received among our neighbours across the channel to allow me to flatter myself that they would not give rise to objections. Such objections were in fact made. At first they made a timid and anonymous appearance in obscure corners of the political papers. Soon, however, Mr. Ainger, an engineer, came forward, made a collection of them for which he became responsibe, and out of which he composed a formal refutation. Mr. Ainger was little known to the scientific world; his name did not call to mind any work which commanded confidence. I had, therefore, every reason to suppose that the refutation of my memoir, announced moreover with a good deal of parade, would be judged impartially and according to its real merit. I think this was not the case: the Quarterly Journal of the Royal Institution opened its columns eagerly to him, enriched his remarks with numerous and beautiful wood cuts, and many lectures in the fine saloons of *Albemarle street*, supplied the unavoidable tardiness of the press; my defeat, finally, was stated in all quarters to be complete, irrevocable and humiliating: I had not quoted faithfully; my illustrations teemed with inaccuracies.

I had abstained, knowingly, from speaking of many authors, both ancient and modern, from which the French mechanicians must needs have derived their pretended inventions, etc. etc.

I did not think I ought to rest quietly under the weight of such grave imputations, and as soon as Mr. Ainger's article appeared, I refuted it. My antagonist had lost sight of the rules of common courtesy; I was weak enough to get angry at this, and to reply with a wamth, which, however great the provocation, could not become the pages of *l'Annuaire du Bureau des Longitudes*. No other proper means of publication occurring to me at the time, I threw my manuscript into a box, from whence, probably, it would never have emerged, but for the singular circumstance which I am about to relate.

I was going to give, lately, my sanction to the last proof sheet of the republication of my memoir, when I received from Dr. *Mease*, of Philadelphia, an article upon the steam engine comprising a part of the American edition of *Dr. Brewster's Encyclopedia*. This article contains, without any critical commentary, a part of Mr. Ainger's memoir; but, in the letter which accompanied it, Dr. *Mease* expresses his regret at not being able to procure my answer, and engages to introduce it in a supplement as soon as it shall reach him. A well informed person, and friendly towards me, deceived by

Mr. Ainger's confident tone, has attributed, then, some weight to his arguments. I confess that I did not believe it possible; I confess that I reposed with confidence upon these few words which an English *savant*, whom all the world will admit as a judge in such a case, addressed to me in 1834. "What you have endeavoured to establish in your history of the steam engine is to my mind mathematically proved." But since this conviction does not yet exist on the other side of the Atlantic, I have determined, for the sake of science as well as, why should I not avow it, for the sake of national glory, to disinter a writing which I had condemned to oblivion. I give it, moreover, as it was written eight years ago, with the exception of some suppressions, the reasons for which I have already hinted at. To speak frankly, I even fear that these suppressions have not been numerous enough, and that there may remain here and there a trace of the warmth of my first rejoinder; but I have not had time to make further alterations.

The criticisms of Mr. Ainger are of two kinds. In the first he reproaches me with a host of supposed errors, the guilt of which I might have incurred without altering the merits of the question in the slightest degree. The second are more serious in their nature, for if Mr. Ainger were in the right I should be greatly to blame for introducing French names into the history of the steam engine; these require minute examination. Let us enter at once into the details of the criticism.

The notice in the *Annuaire*, "has excited (says Mr. Ainger) more attention than might have been thought due to so hackneyed a subject. . . . The cause of that attention will, perhaps, be found in the preface by which the paper is introduced." An author is not responsible for the notice, whether deserved or not, which the public condescends to give to his works; therefore I might have refrained from noticing my critic's explosion of ill-humor, did it not furnish me with an opportunity, the only one I shall probably find in this article, of approaching to an agreement in opinion with him. Moreover the testimony which he has been kind enough to transmit me of the indulgence of the public, will account for the value I set upon proving that in default of all other merit, the article in the *Annuaire* possesses that of accuracy.

According to Mr. Ainger, I have charged "all the English writers (one only excepted) with having sacrificed the truth to their national prejudices." That this assertion has no foundation requires no other proof than this single passage. "When Messrs. Young, Robison, Partington, Tredgold, Millington, Nicholson, Lardner, etc., introduced the Marquis of Worcester as the inventor of the steam engine, Solomon de Caus' works were, *without doubt*, unknown to them." If credit is not given to the sincerity of this declaration, I will observe that among the seven names just read, is that of an illustrious *savant* (Thomas Young) of whom science has been lately deprived by a premature death, and the advantage of whose friendship I enjoyed for many years.

Thus I have not said, I could not say that *all* the English authors, Mr. Stuart excepted, had knowingly deviated from the truth; the reader will in a moment decide for himself on the other hand whether these same authors have given proof of their impartiality.

According to Mr. Ainger the figure borrowed from Solomon de Caus of an engine for raising water by the action of fire, which accompanies the description in my memoir, is inaccurate: the ascending tube and the little pipe which serves to introduce the liquid into the metallic ball, are both too long

A second alteration consists in the suppression of the dilated sheet of water which terminates the ascending jet. I confess, that having no argument to offer upon the length of these tubes; I did not enjoin the person who copied the figure to preserve the proportions of the original drawing. As to the sheet of water, the engraver suppressed it to simplify his work. Mr. Ainger might have added that he has not figured the water in the ball and that the burning sticks placed under it do not perfectly resemble those of Solomon de Caus. I recommend these observations to his attention in case his pamphlet reaches a second edition. The extreme futility of the criticism just noticed ought not to prevent me from making a brief remark. I have no where announced either that Hiero's figure, or that of Solomon de Caus, were copied minutely or in exact geometrical proportion; thus Mr. Ainger exposed himself to severe observations when he said: "M. Arago gives the figure as an extract from the same work (that of Solomon de Caus)."

Observing that Mr. Ainger, in the article Savery, returns a second time to this lengthening of the tube, which he presents as an important alteration, and one made on purpose, I have had the curiosity to apply a compass to the tube in the figure given in the *Annuaire*, and to the jet figured in the work of Solomon de Caus; and it appears that the jet is nearly a third larger than the tube. Thus Mr. Ainger has reduced himself to the choice of an alternative, either to retract his abusive insinuations or to maintain that the power in virtue of which a jet of water rises in the air would not carry the liquid the same height in a tube. I would charitably persuade him not to make this choice until after having consulted a treatise upon hydraulics.

This elongation of the tube appears to have been a real windfall in Mr. Ainger's eyes. He makes the best of it in every way; he would not cut off a millemetre of it for a treasure, and yet the whole amounted to this, that it appeared to him very long, since he declares, page 330, that the two tubes are *indefinitely elongated*. I have just said that the tube is shorter than the jet in the original; thus, whatever malice may be exercised in the case, this fact must be recognized, that the alteration, if alteration there be, has not been made with the intention of adding to the power of the engine. If I had thought and I ought to insist upon the great height to which steam, in the apparatus of de Caus, could raise water, I should have shewn it not by a figure without a scale, but by reference to this phrase, already cited: "The violence is great when the water is converted into air by means of fire . . . . it is certain that if the said ball (a copper ball containing water) is placed upon a large fire so that it may get very hot, it will cause so violent a compression that the ball will split in pieces."

In writing the history of the steam engine, I thought that the best way of fixing the attention of the reader would be to show, step by step, in what respect each new plan improved the engine already existing. It is in this way, for instance, that I have analysed all the improvements which Savery made in Solomon de Caus' engine. This method appears to have singularly displeased Mr. Ainger; to explain Savery's engine, and to explain it clearly without finding it necessary to resort to a figure, is quite shameful in his eyes; he does not say that the description is inaccurate or that it appears to him insufficient, and the sin of omission, therefore, with which he reproaches me was only conjured up by way of a make weight.

Whoever should entertain the idea of not limiting his responsibility to the strict signification of his words, and should be imprudent enought to extend it *to the consequences* which might be deduced from them, would find certain commentators who would soon make him repent his rashness. Two

little illustrations having appeared to me necessary to explain the ideas which directed Papin in the various attempts to which he devoted himself before he contrived the atmospheric steam engine, I placed them in the memoir published in the *Annuaire* at the head of the arguments of which they were, in some degree, the illustration. What does Mr. Ainger on this occasion? He says that these illustration being immediately under the title, *Denis Papin*, "the reader of course concludes are the description of Papin's invention; but," adds he, "it will hardly be believed that they are nothing of the sort, they are the descriptions of the apparatus of the Englishman, Newcomen, made fifteen years afterwards."

My answer will be very simple: as a general position I do not accept of the *conclusions* which the first-comer takes a fancy to draw from my words; I do not feel myself strong enough to resist this sort of attack; I will add in this particular case, that having nowhere said: "the two figures which I make use of are taken from Papin's works," it should affect me but little to have my critic cry out that they are not to be found there; but I have a perfect right to maintain that they are there, for the engine in which Papin proposed to cause a vacuum under the piston by the aid of a separate hydraulic wheel, is no other than that which I have given a drawing of, excepting this single modification; that the valve, or rather the cock, intended to admit the air, instead of being situated under the metallic plate which supports the cylinder, as in my drawing, is on one side at the end of a little horizontal tube issuing from the bottom of this same cylinder. If, profiting by the inexperience which the readers of a journal may have in the contrivances of mechanists, Mr. Ainger has pretended to establish the belief that such a displacement of the valve or cock had been made with the view of improving Papin's plan, I will remark that in modern engines the valve is never at the bottom of the cylinder and that it is always, as in the genuine illustration of Papin, upon the nearly horizontal tube which supplies the steam. M. Arago, says Mr. Ainger, "gives six pages to the description of this apparatus (Papin's,) in which *he brings the steam into the cylinder from the boiler*, through the valve *a*," (that of the lower plate.) I am really sorry that my antagonist so often obliges me to answer him by a simple denial; but in truth I cannot admit his version, as I said: "the water which furnished the steam in these first attempts, *was not contained in a separate boiler*, it was deposited in the cylinder upon the metallic plate which stopped it below." In the whole of the remainder of the article nothing more is said about the production of steam.

Papin proposed two kinds of steam engines. The first, that of 1690, is the engine with a piston, known, since its improved construction by Newcomen, by the name of the atmospheric engine; the other, described in 1707, depended upon different principles, and was simply intended for raising water. I have not room here to discuss the different criticisms of which this last engine has been the subject; I will grant then, if it is desired, that they are all well founded; but what of that? We can only conclude that Papin was more clever or more fortunate in 1690 that in 1707; that his mind was enfeebled by age; that at the second period of time the whole merit of the discovery which he had made seventeen years before, had ceased to be as vividly impressed upon his memory; but in what does all this weaken his right to the invention. Did Newton cease to be author of the Principia or of his Optics after he had witten an inferior treatise upon chronology.

The trouble, therefore, that Mr. Ainger and other writers have given themselves to criticise the *second* engine (invented in 1707) is thrown away

Though Papin should have been crazy at the time, though he should have been confined in a mad house, his engine of 1690 would, nevertheless, remain the germ of all the steam engines in existence. Besides, it is not difficult perhaps to find a plausible motive for Papin's abandonment of his first project: it probably lay in the difficulty in casting and boring out the cylinders which he would have required. In 1695 this difficulty, which in our days has entirely disappeared, seemed to him so great that he proposed to establish a manufactory expressly for the purpose of making the tubes intended to compose the cylinders of such of his engines as should be made use of to propel vessels.

Mr. Ainger does not admit the doubts which I have raised respecting the interpretation hitherto given to a passage relative to the boiler which Worcester proposed to make use of. Want of space obliges me to submit to judgment by default in this case, although, if it were worth the trouble, I could cite one of the most celebrated English engineers in support of my opinion. The same motive prevents me from correcting one or two really singular mistakes into which Mr. Ainger has fallen in an irrelevant display of erudition on the subject of an experiment of Otto de Guerike.* I hasten then to come to his great objections.

However slight the attention which may have been given to the working of a steam engine, two things of capital importance are apparent: in the first place the idea of employing the elastic power of steam as a principle of motion; secondly, the idea, not less important, of getting rid of this steam by condensation, as soon as it has operated.

Should the person, who first reflecting upon the prodigious elasticity which steam acquires when it is produced at a high temperature, have shewn that it might be used to raise great weights; he who has been the first to propose and describe an engine in which the elasticity of steam was the sole priciple of useful operation in the arts; should this person, I repeat, be considered as the inventor of the steam engine? Such is the first question to which the history of this engine gives birth; and one which has been answered affirmatively in all the works with which I am acquainted. Thomas Young, Robison, Partington, Tredgold, Millington, Lardner, Nicholson, etc., are unanimous in this respect. For my part I have only adhered to the opinion of so many able natural philosophers and engineers, and differ from them but in one point: in England the discovery is generally attributed to the Marquis of Worcester, I maintain that it is due to Solomon de Caus, because this engineer's work contains the figure and the description of an engine intended to raise water by the action of steam; because the Marquis of Worcester's, of which moreover the form is not known, had precisely the same object, and because the little which is known with regard to it did not appear until 1663, forty-eight years after the publication of *La Raison des Forces Mouvantes.*

Here Mr. Ainger enters the lists, who also discovers an engine intended for raising water, in J. B. Porta, an author older than Solomon de Caus. If this be the case, the name of Solomon de Caus, which I have substituted for that of Worcester, ought, without doubt, to make way in turn for the name of Porta. Therefore I proceed at once to verify Mr. Ainger's assertion, without dwelling upon the singularity of the circumstance that the

* We cannot consider this as an irrelevant display of erudition on the part of Mr. Ainger, as Otto de Guerike certainly did raise a weight by the descent of a piston before Papin had any such idea. That he made a vacuum under the piston by an air pump does not invalidate this claim.—Trans.

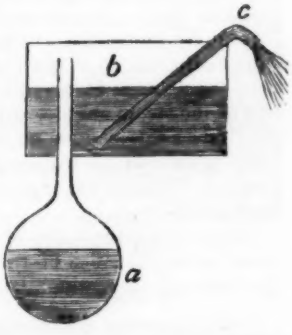
name of the Neapolitan *savant* should never have been mentioned as long as Worcester enjoyed, without dispute, the title of inventor, and that it should have been called to mind as soon as it seemed to militate against the rights of a French author.

The Neapolitan philosopher's engine is found, says Mr. Ainger, "*in a translation* of the work of Hiero of Alexandria, which was published in Italian by Baptista Porta, in 1606," (pages 326 and 327.) I read further on (page 344,) "The reader who wishes to verify the statements here given may consult the different editions of Hiero's Spiritalia, and especially the *translation* in 1606, by Porta, entitled: *I tre libri Spiritalia*, of which a copy is in the British museum."

When the article in the *Quarterly Journal* reached me, I had glanced over various editions of Hiero's work, but I did not know that of Porta which Mr. Ainger cites. At first I reproached myself for this negligence, but, upon investigation, assisted by our most celebrated bibliographers, it was discovered that the work in question does not exist; that, in fact, there is no translation of Hiero by Porta. This author, it is true, has published a work, *in latin* entitled, like that of the Greek mechanician, (*Pneumaticorum libri tres*, Naples, 1601, in quarto) but it is no more the work of Hiero than Buffon's natural history is a translation of Aristotle's. The Pneumatics of Porta, translated into Italian and Spanish by a person called Juan Escrivano, were published in 1606 with the title of: *I tre libri de Spiritali de Giovam. Battista della Porta Napolitano*, in a small quarto volume. This is the book which Mr. Ainger has taken for an Italian translation made by Porta, while it is actually by Juan Escrivano; for a translation of the Greek work by Hiero, while it is a translation of a Latin work by Porta. Mr. Ainger has succeeded in uniting upon this point all the errors into which it was possible to fall.

In the seventy-fifth page of Porta's *Spiritali*, published by Escrivano, is found the apparatus which Mr. Ainger cites as an engine for raising water by means of the elastic power of steam, as a great improvement of an engine by Hiero, of which I shall soon have occasion to speak. I will here give a translation of the chapter of Porta, or rather of the chapter of Escrivano, for it does not exist in the original, and it will then appear how far Mr. Ainger has brought his inventive genius into play.

"Chapter VII.—To know into how many parts a simple portion of water is transformed.



"Make a box of glass or tin, the bottom of which should be pierced with a hole, through which shall pass the neck of a bottle used for distilling, containing one or two ounces of water. The neck shall be soldered to the bottom of the box, so that nothing can escape there. From the same bottom shall proceed a pipe, the opening of which shall almost touch it, leaving just room enough between them for the water to run. This pipe shall pass through an opening in the lid of the box, and extend itself on the outside to a small distance from its surface, (passi per lo coverchio fuori poco lontano dalla sua superficia.) The box must be filled with water by a funnel, which is afterwards to be well closed, so as not to allow the air to escape, (che non

posso respirarè); finally, the bottle must be placed upon the fire and heated a little, then the water, changed into steam, will act violently upon the water in the box, and will make it pass through the pipe *c* and flow off on the outside. The water must be kept heated, in this way, until no more of it remains; and as long as the water shall smoke (*sfumera*) the air will press the water in the box, and the water will flow off on the outside. The evaporation being finished, you may measure how much water has gone out of the box, and there will remain in it as much water as shall have passed out of it, (the bottle) and from that you can conclude how much water has run out, and into how much air it has been changed. You may also easily calculate how many parts of lighter air an ounce of air of ordinary consistence is capable of giving."

Let us now recall the manner in which Mr. Ainger announces this passage.

"A translation, says he, of the work of Hiero's, was published in Italian, by Baptista Porta, in 1606, he repeats Hiero's invention, and adds the following of his own, illustrated by a diagram, in which is shewn the furnace for heating the water."

The truth is, that Porta does not speak at all of Hiero's machine; that he had no kind of intention of improving it; that he did not even dream of making an engine; that his aim, his whole aim, was to determine experimentally, and by a method, all the faults of which it is useless here to point out, the relative bulk of a given quantity of water, and of the steam into which it is transformed by heat. Porta had so little idea of proposing his apparatus as a fit one for raising water, that he says in formal terms that the pipe by which the water flows off passes to a small distance from the lid of the small box. I have no wish to deny that Porta was not ignorant that steam could propel a liquid in the same way as air; but nothing, absolutely nothing, proves that he had the least idea of the great power which steam is susceptible of acquiring, and of the possibility of employing it as an effective moving power. Porta, the most enthusiastic of contrivers mentioned in the history of the sciences, would not certainly have neglected to speak of this particular motion if he had ever entertained it. Moreover, the whole effect of Porta's experiment would have been equally produced, if his large bottle in lieu of water had only contained air.*

The double idea that steam properly enclosed, raises water above its level, and that it is capable of producing the greatest effect; that therefore, it might be used in the construction of useful engines, is found, for the first time to my knowledge, in the work of Solomon de Caus. Perhaps something analogous to it may be found in older authors. Very well! in that case, the name of Solomon de Caus, I repeat, must disappear from the history of the steam engine, as I have erased from it the Marquis of Worcester; but, unless this new name belongs to some personage born in the British isles, there will be still room for correcting this assertion so often reproduced. "The steam engine has been the invention of a few individuals, all Englishmen."

Many enlightened men of science and mechanicians attach small importance to the first idea of the application of steam as a motive power. The ancients, say they, who attributed earthquakes to the instantaneous develop-

*Notwithstanding this laboured argument, it appears to me, that if the figure given of Porta's machine is correct, it is the true germ of the engine for raising water, afterwards used by Savery; without, however, using the principle of condensation.

TRANS.

ments of steam; the mechanician who proposed to make all the planks of his neighbour's house move backwards and forwards by means of the same agent, knew as much, and have said as much about it, in the main, as Solomon de Caus, or Worcester. If there existed, they add, a useful draining machine in which the immediate action of steam raised a liquid, one might imagine the importance which has been attached to the experiments of these two French and English engineers; one might then, on the score of a first germ, give a moment's attention to the metallic ball of the first and the obscure descriptions of the second; but there is no analogy to be traced between them and the steam engines now in use. The invention of these engines consist entirely then in a cylinder in which a piston moves with an alternate rectilinear motion, and in the means of obtaining this effect. If the first employment of steam in any apparatus as a principle of motion, gives a right to the title of inventor, Hiero of Alexandria deserves the distinction; the rotary engine of this mechanician has been very properly set aside in the contest, because it has neither in shape nor in the manner in which the steam operates any affinity with the engines of our days; those then of Solomon de Caus and Worcester, which have no greater resemblance, should be in like manner set aside. The velocity of water is equally the cause of motion in an undershot water wheel, and of the ascent of the liquid in the hydraulic ram; if it had been concluded from that circumstance, that the inventor of the wheel ought also to be considered the inventor of the ram, every body would have exclaimed against it; and yet, with regard to steam engines this has been the mode of reasoning without its having been perceived. Caus or Worcester, placed to day, with the knowledge of their era, before one of Watts' engines in operation; would neither the one or the other of them even suspect that steam was the cause of motion; and yet they are called the inventors of it!

While citing these reflections, I have given them all their weight. It would be an error to conclude from this, however, that I adopt them without modification. I grant very willingly, that the inventors of the engine with a piston, of the alternate movement, and the contrivances which produce it, ought to be placed in the foreground; this concession made, I cannot admit that the first idea of employing steam as a principle of motion ought not to figure in the history of the steam engine actually in use.

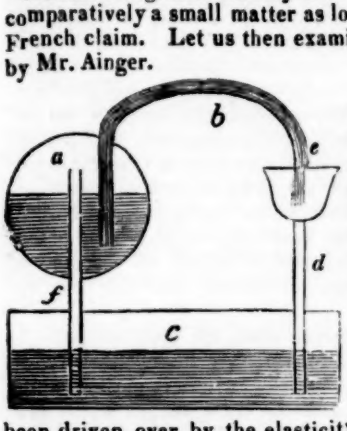
Moreover, it is just to acknowledge, and it is an error from which I have not myself entirely escaped, that it is wrong to consider the steam engine as a simple machine, the inventor of which we must absolutely find. What conclusion could have been drawn, for instance, if this method had been pursued in writing the history of watch making? who is the inventor of a watch? nobody; but it is natural to ask who is the inventor of the various escapements, the compensating balance, &c. &c. In the steam engine, also, there exists many capital ideas which would not have emanated from the same brain. The object of the historian ought to be, to class them in the order of their importance, to give to each inventor that which belongs to him, and to set down exactly the dates of the various publications. In attempting last year to acquit myself of this task, I thus pointed out the characteristic features of the engines now in use.

The idea of a steam engine having a piston operating with an alternate movement.

The production of this alternate motion, by a combination of the elastic force of steam with the property of condensing.

The various, and more or less advantageous ways of effecting this cooling.

No one will dispute that these are the principal features of the engines in use. But I have proved in 1829, that the first two ideas belong to Papin. To admit the truth of my demonstration, would have been to put a stop to the controversy, to confess that the French have been very instrumental in the invention of the steam engine. Great care has therefore been taken not to make this concession. Nevertheless, Papin's publication is indisputably older by many years than those of Savery, Newcomen, and Cawley; the discussion could not be sustained on that ground, and Mr. Ainger, who doubtless perceived it, has chosen an entirely different one: he has decided, cost what it may, that Papin's discovery should be found in some more ancient author, and he has pitched upon Hiero of Alexandria. It is very true, that by this, a new and wide breach is made in the assertion, that: "the steam engine is entirely due to Englishmen;" but the inconvenience is comparatively a small matter as long as it is successful in excluding every French claim. Let us then examine the new claims of Hiero, discovered by Mr. Ainger.



"In another apparatus of Hiero, says Mr. Ainger, *a* is a globe half filled with water, which is partly converted into vapour by exposure to the sun. A pressure is thus occasioned on the surface of the water, which is consequently drawn up through *b*, the Siphon, into the cup *e*, whence it descends by the pipe *d* into the close vessel *c*, also, half filled with water. When the globe *a* cools, the water it contains is relieved from the greater part of its pressure by condensation, and the water rises from the vessel *c* through the pipe *f* to supply what had been driven over by the elasticity of the vapor. Thus the water is alternately expelled from, and restored to the globe, by the alternate production and condensation of elastic vapour, (p. 326.)"

"This apparatus, says Mr. Ainger, anticipates the principle of both the contrivances on which M. Arago builds his theory, that the steam engine is a French invention."

This is not all; I read in the 337th page of Mr. Ainger's memoir: the apparatus in which Papin created the alternate motion of a piston by the production and condensation of steam, does nothing more than illustrate "a well known physical fact. That a vacuum was left by condensed steam was known from the time of Hiero at least," and further on in the 338th page, "Papin was not the first by 2000 years, who saw that condensed aqueous vapour left a vacuum." . . . . . "Papin's apparatus does not use both the elastic force and condensation of the steam, and if it had, he was not the first who combined in the same machine the elastic force of the vapour and its condensability, for Hiero's apparatus does the same thing."

I have some difficulty, I confess, in suppressing the expression of the sentiments to which these various paragraphs unavoidably give rise. The reader, however, will supply it, for I shall place in face of all these passages in which such explicit mention is made of *vapour* produced, and *vapour* condensed, a faithful translation of the explanation which Hiero has given of

his apparatus. I say a *faithful* translation, and no one will doubt it when I state that I have applied to Mr. Letronne, that I might have, as it were, a legal, and unexceptionable authority.

"Let ACDB be a closed basis, across which passes a funnel, the pipe of which shall be not far from the bottom (of this basis); let there be (moreover) a globe EF, from which a tube shall descend in the base to a small distance from the bottom of the apparatus. A curved siphon is fitted in such a way as to penetrate into the water in the globe. As soon then as the sun comes to strike this globe, the air which it contains being heated will press the liquid; the latter will escape through the siphon and will descend into the base by the funnel. But when the apparatus is in the shade, the air (less dilated) making room in the globe, the tube will take up the liquid again. This phenomenon will occur as often as the sun strikes the globe." (The words in parenthesis are added to the text for the sake of clearness.)

The reader has now before his eyes the passage, but the unaltered passage, according to which they would deprive Papin of the honour which so lawfully belongs to him, of having been the first to employ steam to make a vacuum under the piston, and to give the crank an alternate motion. I beg him therefore to have the kindness to compare the words of the Greek author with Mr. Ainger's explanation, and he will see that the words *vapor, elastic vapor, condensation of vapor to produce a vacuum*, are pure inventions; that Hiero says nothing about them, that he did not dream of it; that his aim, his only aim is to make use of the elastic power of the AIR contained *in the globe* EF, although the word *air* does not once occur in the paraphrase of the English author.

Mr. Ainger could not suppose that I would leave his memoir unanswered. How then are we to explain the numerous and important alterations to which he has subjected the words of Hiero of Alexandria?

The question is not certainly one of easy solution; this is, however, the manner in which Mr. Ainger perhaps has reasoned.

Since the apparatus of the Greek mechanician contained water, there was in his globe vapor mixed with air; this vapor must have been more abundant as it became warmer; (we know it now perfectly;) therefore nothing hinders me from affirming that the movement of the liquid was owing to the vapor's being more elastic during the day than in the night. It may be said, perhaps, that the effect arising from this cause, was but a very small part of that occasioned by the expansion of the air; but as soon as the discussion bears only upon quantities, it will terminate in my favor.

The reply is simple, that the question is not whether there was a small quantity of vapor in operation in Hiero's apparatus, but whether this mechanician had suspected it; now Hiero only speaks of air. If we must record, as the discoveries of an experimenter, all the phenomena which his operations realize, the analysis of atmospheric air no longer belongs to Lavoisier, since the first person in whose hands a piece of metal rusted had, without suspecting it, separated oxygen from nitrogen; Black would not be the inventor of the theory of latent heat, because water was never made to boil without the steam's acquiring, inevitably, the great quantity of caloric, which its constitution requires; the discovery of electricity by contact would no longer belong to Volta; but really to him who first placed two metallic substances of different natures one upon the other, &c. &c.

Finally, I am bound to say, Mr. Ainger, led away by his zeal, has even deprived himself of the use of the arguments which I have just opposed. To be convinced of it, it is sufficient to recall this phrase: "It has been

known *since the time of Hiero*," &c.; or, indeed, this other: "the apparatus of Papin only served to illustrate *a well known fact*, as," &c.

In the various quotations which I have been obliged to present him, the reader will certainly have remarked this passage: "*Papin's apparatus does not use both the elastic force and condensation of the steam.*"

After such a phrase, all discussion becomes impossible. What concession, in fact, can one expect from an opponent determined to gainsay evidence? Papin say you did not use the elastic force and condensation of the steam! But why then *did he put water* upon the lower plate of his cylinder? *Why did he make it boil* when he wanted to give the piston an ascending motion? Why did he take away the fire when the moment arrived to make the piston descend under the action of atmospheric pressure?

Mr. Ainger's unqualified *(inqualifiables)* denials are, without doubt, very astonishing; but it ought to be still more surprising, that a memoir destitute to such a degree of all spirit of justice, of all truth, and of all logic, could have been uttered, listened to, received in an institution once dignified so highly by the lessons of Humphrey Davy, and of Thomas Young, in an establishment which even now has the inestimable advantage of numbering among its professors, learned men of the merit of Messrs. Farraday and Millington. But, every thing considered, these powerless efforts of passion, or of national prejudice, are a solemn homage rendered to Papin's inventions. I do not hesitate then again to state the three important propositions which ended the analysis of this engineer's labors in my historical notice. Mr. Ainger will, unintentionally, have contributed an incontestible evidence in their favor.

Papin contrived the first steam engine with a piston;

Papin was the first to observe that aqueous vapor furnished the means of making a vacuum in any space, however great;

Papin was the first who thought of combining, in the same steam engine, the elastic force of steam with its property, which he pointed out, of condensation by cold.

On the analysis of limestones, especially the Magnesian kind, and a method of completely separating Lime from Magnesia, when both are present in large quantity. *By* Robert E. Rogers, *M. D., and* Martin H. Boye'.

Carbonate of Lime, associated with more or less carbonate of Magnesia, forms the principal ingredient of limestones. In some varieties the latter substance appears only as a trace, while in others, it amounts to nearly 50 per cent. of the mass. When the proportion of the carbonate of Magnesia is very considerable, the rock is termed Magnesian limestone, or Dolomite, the latter name being mostly applied to the crystalline varieties. Variable quantities of other substances, as Silica, Alumina, and the Oxides of Iron, and Manganese, are generally associated to some extent with the above principal constituents.

The Silica is usually either in the free state, in the form of small transparent grains of quartzose sand, sometimes impalpably minute, or in chemical combination with the alumina and iron, (clays, &c.)

The extensive use made of limestones in the arts and agriculture, as mortars, cements, fluxes and manures, renders it a matter of great importance to procure a certain and expeditious process for their analysis, especially as there exists great diversity of opinion respecting the relative efficiency of the several constituents.

We proceed to describe a mode of analysing calcareous carbonates, which

we have found in practice both certain and expeditious, and therefore, preferable, we conceive, to the methods generally in use, which demand extreme care and considerable time to furnish accurate results. The method here proposed, we have adopted with success in an extensive series of analyses performed for the geological survey of the state.

The limestone is first finely powdered, when a given weight, about 30 grains, is digested in chlorohydric acid in the ordinary way, evaporated to dryness, moistened with chlorohydric acid, and redissolved and filtered. The silica and a large part of the other adventitious substances are thus left upon the filter. They are then calcined and weighed, a correction being made for the weight of the ashes of the filter. These steps give the amount of the *insoluble matter*.

The filtered solution, containing besides the lime and magnesia, portions of alumine and oxides of iron and manganese, is neutralized with ammonia, avoiding an excess, and then precipitated with sulphhydrate of ammonium, a small quantity of which will usually suffice. When the precipitate has subsided, it is filtered, the funnel being covered with a glass plate, so as to exclude the atmosphere, and then washed with water containing a few drops of the sulphhydrate of ammonium. The filter with its contents, is then removed, pressed between bibulous paper, dried and calcined. The alumina, and oxides of iron and manganese are thus obtained together. When their quantity is such as to require them to be separately estimated, it can be done in the ordinary way.

In determining the lime and magnesia, a fresh equal portion of the powdered mineral is employed, which is decomposed by a sufficient quantity of dilute sulphuric acid, with the aid of heat. Water is then added so as to fill the vessel up to a given mark, after which alcohol of known strength is introduced in such proportion as to make the whole solution contain 40 to 41 per cent., (estimated by volume) of alcohol. The alcoholic solution of this strength* precipitates entirely the *sulphate of lime* along with the insoluble matters. When the precipitate is settled, it is filtered under cover of a glass plate, and repeatedly washed with dilute alcohol of the same strength, as that previously employed, until a barytic solution indicates no trace of sulphuric acid. The whole is now calcined, and the weight of the insoluble matters as already ascertained, being deducted, we obtain the amount of *sulphate of lime*, from which we compute that of the *carbonate*.

The filtered solution now contains the sulphate of magnesia, and an inconsiderable portion of the sulphates of alumina, iron and manganese, besides an excess of sulphuric acid. It is to be evaporated until all the alcohol is dispelled, and then precipitated by pure carbonate of potassa with the precautions usually prescribed. The magnesia, alumina and oxides of iron and manganese, thus precipiated, are filtered, washed and calcined. Subtracting from the weight of the whole, that of the three latter previously ascertained, we find the amount of the magnesia, which is to be estimated as carbonate.

The separation of the lime in the form of sulphate from magnesia, by an alcoholic solution, is so complete, as to make it unnecessary to estimate directly the magnesia, except when we desire to check one result by the other. The above process, it need hardly be said, will apply equally to the analysis

* Alcohol of this strength has a *specific gravity* of 0.951 to 0.949 at 60° Far: and marks between 17° and 18° Baumé. Alcohol of the shops (alcohol rectificatus Lond. Phar.) marking 54½ Pennsylvania proof—has a specific gravity of 0.835. Five volumes of this, and 6 a 6½ volumes of water, will give a very suitable mixture for the above purpose of analysis.

of other substances than limestones, in which lime and magnesia abound, for we have only to precipitate these earths as carbonates, convert them into sulphates, and then treat them with dilute alcohol after the manner described.

We present the following analyses by way of illustration.

1. A white crystalline dolomite, from the neighbourhood of Montville, New Jersey. *Specific gravity*—2.853.

A portion, 1.469 grammes, was raised to a dull red heat, and the water, which was received in a tube containing chloride of calcium, was found to weigh .007 grm. or .48 per cent. This small amount of water is not expelled at the temperature of boiling water.

Two other portions of the powdered mineral, treated after the method described, gave these results:

Insoluble matter,	.04 per cent.
Alumina, Ox. Iron, and Ox. Manganese,	.15
Sulphate of Lime, and insol. matter,	76.09
Magnesia, Alumina, and Oxides of Iron and Manganese,	20.70

By subtracting the insoluble matter .04 from the joint weight of the insoluble matter and sulphate of lime 76.09, we get 76.05, and subtracting the alumina and oxides of iron and manganese from the joint weight of these and the magnesia, we have for the magnesia 20.55.

A reference to the annexed table, the use of which will be explained, shews that 76.05 per cent. of Sulphate of lime is equivalent to 31.54 per cent. of lime, or to 56.11 per cent. of carbonate of lime.

It also appears that 20.55 per cent. of magnesia is equivalent to 42.54 of carbonate of magnesia. The result will therefore stand thus;

Carbonate of Lime,	56.11
Carbonate of Magnesia,	42.54
Alumina and Oxides of Iron and Manganese,	0.15
Insoluble matter,	0.04
Water,	0.48
	99.32

Were we to estimate the magnesia in this case by the loss, it would be 43.22

Table for calculating Lime and Carbonate of Lime from the Sulphate of or its Sulphate.*

		1	2
Sulphate of Lime	Lime	0.41532	0.83064
Sulphate of Lime	Carbonate of Lime	0.73780	1.47561
Magnesia	Carbonate of Magnesia	2.07002	4.14004
Sulphate of Magnesia	Magnesia	0.34015	0.68030

The first vertical column of the table contains the names of the substances, from a known weight of which we wish to compute the weight of the substances embraced in the second column. The figures in the horizontal lines represent the quantities of the substances named in the second verti-

* This table is taken partly from H. Rose's Analytical Chemistry, vol. ii, and partly calculated for the present purpose. The principle of this method of calculating analytical results was first set forth by Poggendorf, in his Annals, vol. xxi, and has since been extensively carried out by H. Rose in his work just mentioned.

carbonate of magn. equivalent to 20.88 magnesia, or, 0.33 per cent. more than the amount found by direct estimation.

With a view further to shew that the *whole* of the lime is procured by the above method, and therefore, that we may safely estimate the magnesia by subtracting the carbonate of lime and other ingredients directly got from the weight of the mass, we subjoin the following example of a specimen found to contain no magnesia.

2. A white crystalline, imperfectly saccharoidal limestone, from near the mouth of Yellow Breeches Creek, Susquehanna River, Pa.

From one portion of the powdered mineral, treated with chlorohydric acid we obtained

Insoluble matter,	2.3 per cent.
Alumina,	1.2 "
Ox. of Iron and Manganese,	*none*

Another portion treated with sulphuric acid and diluted alcohol of the proper strength, gave

Insoluble matter and Sulph. Lime,	133.19

Subtracting the insoluble matter, 2.3, from the sulphate of lime and insoluble matter, we have sulphate of lime 130.89 per cent., which is equivalent, as the table will show, to 96.3 per cent. of carbonate of lime.

The amount of water as derived from a third portion was 0.2 per cent. Our analysis therefore stands thus:

Composition in 100 parts—	
Carbonate of Lime,	96.3
Carbonate of Magnesia,	none
Alumina,	1.2
Insoluble matter,	2.3
Water,	0.2
	100.0

Lime, and also for calculating the Carbonate of Magnesia from Magnesia

3	4	5	6	7	8	9
1.24596	1.66128	2.07660	2.49102	2.90724	3.32256	3.73788
2.21341	2.95121	3.68902	4.42682	5.16462	5.90242	6.64023
6.21006	8.28009	10.35011	12.42013	14.49015	16.56017	18.63019
1.02045	1.36060	1.70075	2.04009	2.38105	2.72120	3.06135

cal column corresponding to those quantities of the substances in the first column, which are signified by the numbers at the head of each vertical division of the table. An example will render the mode of using the table sufficiently plain.

In the first analysis, the amount of sulphate of lime was 76.05. To ascertain from the table the quantity of carbonate of lime equivalent to this amount of sulphate, we find on the horizontal line appropriated to the carbonate, the quantity due to seven parts of the sulphate—namely 5.16463, then the quantity due to six parts, namely 4.42682, and then that equivalent

to five parts or 3.68902. By arranging these in their proper decimal order, so as to impart to the several amounts taken from the table, the value they are intended to have as units, tenths, hundredths, &c., and then performing a simple addition, we get the amount of carbonate corresponding to the whole quantity of the sulphate.

The figures will stand thus:—

Sulphate of Lime	76.05
	51.6462
	4.42682
	.000000
	368902
Carbonate of Lime	56.1099102

In the same manner, 20.55 of magnesia will be found to be equivalent to 42.54 of carbonate of magnesia—thus:—

Magnesia	20.55
	41.400
	00.000
	1.035
	.103
Carbonate of Magnesia	42.538

As it may be sometimes convenient to evaporate the magnesian solution to dryness; ignite it, and from the sulphate of magnesia thus procured, compute the magnesia or its carbonate, we have introduced into the table a column to facilitate the calculations.

Physical Science.

Examination of the Meteorological Theories of Mr. Espy and Mr. Redfield. By a Correspondent.

There are none of the operations of nature, with which we are in more immediate or sensible contact, or in which all are more intimately concerned,—and yet none, probably, which have been less studied or comprehended, or the facts and principles of which have assumed less of the form of a regular science, than those relating to the *weather*,—or Meteorology. It is true there have been various hypotheses and theories started, with a view to account for the various states and changes that are observed to occur in our atmosphere. And one theory, the Huttonian, from its superior plausibility, and for the want of a better, has become generally current.

That the Huttonian theory of storms is free from difficulties and objections, no one who has studied the subject closely, will pretend. The phenomenon to which it applies with the least objection, and the only one in fact, in relation to which it has even the appearance of plausibility, is that of *rain*. But even here, it is at fault. It has been demonstrated, (as I think) to be entirely insufficient to account for the *quantity* of rain, which is often observed to fall in a given time. It is no very difficult problem to ascertain the quantities of hot and of cold air of given temperatures, and under given and known states of the atmosphere, that would be required to

be mixed, to deposite a given quantity, say an inch of rain. And it is somewhat surprising that the solution of so important and natural a question, should not have been demanded by scientific men, as a preliminary condition of receiving the theory. The most favorable circumstances supposable, as to the quantities of cold and hot air, the extremes of temperature, the quantity of vapor in solution, &c., would, upon this principle, be insufficient to produce a single inch of rain; even allowing, what is scarcely supposable, that large masses of warm and cold air in the same neighborhood, would of necessity, become thoroughly mixed.

Of late, the subject of meteorology has received far more attention than formerly, both in this country and in Europe. Enquiries and observations of a scientific and comprehensive character have been instituted, which give promise of most important results. There are, in this country, two gentlemen in particular, whose labors in this department of science, have become quite conspicuous; one of whom, has promulgated a new and bold theory, which is creating no little sensation. I, of course, allude to Mr. Espy, and Mr. Redfield. The object of the present paper is to examine briefly, some of the views of these two gentlemen.

Unfortunately, or it may be fortunately, for the cause of science, these two meteorologists have arrayed themselves against each other. Or, rather, Mr. Redfield has assailed with great vehemence the new theory of Mr. Espy; while the latter has, with much zeal, and not less ability, exerted himself to defend and fortify, and extend his peculiar views. Mr. Espy has taken very little pains to controvert any of Mr. Redfield's doctrines, unless it be that of the *whirlwind* character of storms; which the latter supposes he has fully established, and which he appears to consider fatal to Mr. Espy's theory. I am not aware that Mr. Redfield has, as yet, advanced, or advocated any particular theory, as to the cause of storms; though in one of his papers, he intimated that he had constructed, or was constructing a theory, which would be made public in due time.

Mr. Espy's theory is briefly this: He supposes that the air at the surface of the earth becoming rarified, ascends: and carrying up with it a certain amount of vapor which it holds in solution, it rises, (supposing the circumstances to be sufficiently favorable) until by diminished pressure, and consequent expansion, it is cooled down, so that it can no longer retain all its vapor, but deposites a portion of it in the form of cloud; that the latent heat disengaged by condensation, acting upon the air with which it is in contact, greatly increases the upward tendency of the air, and the further condensation of vapor, until it falls to the ground in the form of rain; and that in consequence of this upward current, or vortex at the centre, the air rushes inwards from the outer parts of the storm, to supply the vacuum.

This theory then requires that the wind should blow at the same moment from all the exterior parts of a storm, or perhaps from parts beyond its borders *inwards*, towards the centre. Is this the fact? Mr. Espy alleges that it is; and he has collected a great number of observations from different parts of the country, relating to certain storms, which seem to justify that conclusion, and, so far as they can be relied on, to establish his theory. If this one single fact, an inward motion of the air in the borders of storms, should be established, I cannot see why it would not be conclusive, or nearly so, in favor of Mr. Espy's theory. He maintains, however, that there are many other facts which support it, while there appear to be none that contradict, or are inconsistent with it. He further maintains, not only that all known facts support his theory, but that his theory explains and accounts

for all known facts. He holds that the same laws, as to the disengagement of latent heat, condensation, &c., are in operation, whether in the production of rain, snow, or hail, or in the tornado or the water-spout.

This theory, like every other new doctrine, whether true or false, meets with opposition; some in the shape of argument, but much more in the form of ridicule. Even Mr. Redfield, it must be admitted, has resorted in no small measure to this latter mode of attack. Perhaps he considers it too preposterous to deserve a serious refutation. Certain it is, that with all his apparent anxiety to demolish it, he has taken very little notice of the principles and argument on which it is built. For aught he has said, one might doubt whether he has taken pains to ascertain what the theory is, except in its relation to a single fact, the inward tendency of the air. Of this, I shall have occasion to speak in another place. The same remark applies substantially to nearly all the opposition that has appeared. The real merits of the theory, the principles and reasoning of which it is composed, have scarcely been touched. Indeed, the principles, as such, aside from their applicability to the case in question, probably will never be disputed. They are as well established as any laws in physical science. The theory involves very little, if any thing, that is purely hypothetical; unless it is the *combination* of certain principles.

It may be worth while to state in the form of separate propositions, the leading principles or facts which the theory embraces. Mr. Espy assumes, among other things, as parts of his theory—

That when a portion of air at the surface of the earth, becomes more rarified than the surrounding air, it ascends:

That the atmosphere is capable of containing, and does always contain, a certain quantity of water:

That this capacity of the atmosphere for containing water increases rapidly with the temperature:

That the quantity of water actually in solution, varies greatly at different times and places, independently of the temperature; the air at a given temperature, sometimes being filled nearly or quite to the extent of its capacity, while at others it falls far short of it:

That if from any cause, the temperature of a portion of air, containing a given quantity of vapor, be reduced to a certain point, that is, until the capacity be brought below the dew point, it must deposite a portion of the water:

That expansion arising from diminished pressure, is attended by diminished temperature; that the actual diminution of temperature, on this account, in ascending from the surface of the earth, is about one degree for every hundred yards; and that consequently, air, highly charged with vapor, that is, with a high dew-point, would not have to ascend very far before condensation must commence:

That the condensation of vapor is attended with the disengagement of a very large quantity, more than a thousand degrees of latent heat; in other words, sufficient heat is set at liberty by the condensation of a given quantity of vapor, to raise the temperature of a hundred times that quantity of water ten degrees.

These propositions need no proof. The truth of all of them has been demonstrated a thousand times; and is, I take it, universally admitted. So far then, as they appear to apply to the theory in question, they afford evidence in its favour. But it is not enough that the theory embraces several known truths. It is important to enquire whether they have any obvious

and necessary connexions with each other, and a probable connexion with the phenomena which the theory professes to explain;—whether the action of one principle should, or might, prepare the way for, and bring into play, another, and so on:—Whether it is possible, and if so, whether it is probable that the several principles and conditions should conspire to produce the effect supposed.—Affirmative answers to such enquiries, would afford additional evidence in favour of the theory. How is it in the case before us? Is it probable that the air at a particular place would become so much more rarified than the surrounding air, as to cause it to ascend several hundred yards; and at the same time, that the dew point be so high that before the ascending air should come to an equilibrium its temperature should have sunk to that of the dew point, so that condensation and the formation of cloud should commence? in other words, that the air should ascend as many hundred yards as there are degrees between the dew point and the original temperature? Then is it probable that the heat disengaged by this partial condensation, would be sufficient to continue and increase this upward tendency? that the vacuum thus caused would continue to be supplied by air with a high dew point from below? that the ascending mass would continue to rise until the temperature be so much reduced by diminished pressure, notwithstanding the counteracting influence of the disengaged heat, as to cause a further condensation so copious as to produce rain? To me this does appear sufficiently probable. At least I can discover nothing in it unprobable, much less impossible or absurd.

But after all, the question must be settled by *facts*. And to these Mr. Espy appeals with confidence. The great and fundamental fact which alone, if established, must be decisive, is the inward tendency of the air, in the borders of storms. It is this fact which is chiefly regarded in the controversy with Mr. Redfield. To notice, briefly, this controversy was a leading purpose of the present essay.

Mr. Espy maintains that the air in the borders of storms generally moves inwards; and that this inward motion is the *effect* of an upward current at the centre. Mr. Redfield contends that the motion of the air in the borders of storms is gyratory, or of a whirlwind character: and instead of being the effect is the *cause* of the upward current, if, indeed, such currents exist. What is the cause of this circular motion of the air, he has not attempted to show.

Now that the fact is as Mr. Redfield supposes, I am not at present disposed to deny. It appears to me that Mr. Espy has sufficiently proved that the wind does blow *inward*, to some extent at least; but that it should, before it reaches the centre, assume a gyratory motion, as *water*, in a vessel, flowing through an orifice in the centre of the bottom, is known to do, is, I think, more than probable. That this should take place somewhat remote from the centre, and even influence, materially, the direction of the wind, in the very borders of the storm, I think is not improbable. But what then? Suppose the whirlwind motion be admitted to the full extent of Mr. Redfield's views,—does it follow that the tendency is not inward? By no means. The air moves inwards, according to Mr. Redfield, just as truly, though not so directly, as it does according to Mr. Espy. A glance at the accompanying diagram will make this apparent without a word of explanation.

Indeed, Mr. Redfield himself has admitted, more than once, that there is an "involuted spiral course of the wind, inwards."* And what is there in a *spiral*, or in direct movement inwards, which contradicts, or is inconsistent with the theory of an upward vortex? I can discover nothing. On the other hand, *rejecting* the doctrine of an upward vortex, Mr. Redfield's theory, I apprehend, is chargeable with the very absurdity which he has imputed to Mr. Espy's (but which does not belong to it,) the excessive accumulation of air at the centre of the storm. Without admitting an upward current, operating as the *generating cause*,—not as a *consequence* of the inward motion, there *is* an absurdity in supposing any inward motion whatever, either direct or spiral;—an absurdity, not merely of supposing a central accumulation, contrary to fact, but of supposing the air to move inwards and accumulate from all quarters, *without a cause*, and contrary to known laws. Setting aside the upward central vortex, (which, if admitted, is sufficient not only to prevent any accumulation from the inward motion of the air, but to account for that motion) what possible cause can be assigned for either centripetal or circular motion? If the air moves either directly or spirally towards a particular point, or if it revolves around a given point, there must be some cause for it. Some force must act upon it, either from within or without. Mr. Redfield does not need to be told that the air, as well as all other matter, will always move in straight lines (if it moves at all,) unless it is acted upon by some force, foreign to itself. Circular motion is a *forced* motion; and is always produced in one of two ways. Either the moving body is resisted by some external barrier, as a wall, or it is retained in its orbit by some centripetal force, as a cord, or the attraction of gravitation. It is either *pushed* or *pulled* out of a straight line, into a circle. How does this apply to the case in hand? The air in the borders of a storm certainly cannot be attracted or held by any force at the centre. And, supposing the density to be the same within and without, (which ought to be, if there is no upward tendency, to remove any part of the pressure,) then the outer air could not act as a barrier to resist the centrifugal tendency of the revolving mass within, supposing it possible for a revolving motion to be given to it, so that admitting the "whirlwind" to exist, the tendency must be outwards, instead of inwards.* But what should give the air, in a storm, a whirlwind motion, if it is not the force of the atmospheric pressure without, driving it towards a vortex within? It is easy to conceive of a whirlwind being produced by the rushing of the air from all directions to fill a void occasioned by the withdrawal of a portion at a particular place. But to suppose a mass of air to commence moving in a circle, while there is no tendency to a central vortex, is just as absurd, I apprehend, as to suppose a ball, placed on a horizontal table, to commence moving in a circle.

It will not do to reply to this by alleging the known fact of a diminished pressure at the centre of storms, as indicated by the barometer, to account for the whirlwind; for this would be virtually admitting Mr. Espy's theory.

* Mr. Redfield has once or twice spoken of the depression of the barometer at the centre of storms, as if it was caused by the centrifugal effect of the whirlwind, thus seeming to suppose an *outward* instead of an *inward* motion. This idea is certainly inconsistent with what he says elsewhere of a "spiral course inwards," and of the whirlwind causing an *upward* motion at the centre.

It is very true, that from some cause or other, there *is* a partial vacuum at the centre of storms; which would, naturally enough, account for the inward rush. This barometrical indication is another *fact* which Mr. Espy urges in support of his theory. It is unnecessary to dwell upon it.

There is then, as admitted on all hands, an inward movement of the air; and yet, so far from any *accumulation*, the quantity at the centre is absolutely diminished. The air evidently escapes *somewhere*, and that without being *pushed* away by what comes in from without, as the state of the barometer plainly indicates. Are there any *facts* to prove that this air goes upwards? In ordinary storms, there is, probably, no positive evidence of an upward current, except what is furnished by the facts just stated. And they alone appear to me to be conclusive. But in tornadoes and water-spouts, the evidence of an upward current of great violence is direct and positive. In severe tornadoes it is not unusual for heavy bodies to be raised suddenly and almost perpendicular, hundreds of feet from the surface of the earth; and in water-spouts it is well known that the water is carried up with great violence and in immense quantities, from the surface of the ocean. It is unnecessary to remark that these facts prove the existence of an upward current of immence velocity and force.

On the whole, in view of the facts, and the known laws of heat and condensation, already quoted, I cannot resist the belief that Mr. Espy has discovered and developed the true law of storms. He may be wrong in some of his views; but his theory, as a whole, is supported, if I mistake not, by principles and arguments, not likely to be disproved. If it should bear the test of future observation and scrutiny, the dicovery will form an epoch in the annals of science. In the mean time, it is much to be hoped, and there is reason to expect, that its merits will be thoroughly canvassed, both by its advocates and opponents. The opposition which it encounters is, by no means to be regretted, so far as it is conducted with fairness and candor. If the doctrine is true, opposition, instead of overthrowing, will only help to establish it. If it is fallacious, the sooner the falacy is exposed the better.

L. H. P.

Civil Engineering.

A Popular Exposition of the Incorrectness of the Tariffs of Toll in use on the Public Improvements of the United States. By CHARLES ELLET, Jr., *Civil Engineer.*

The object of this essay is to point out, in a brief and popular view, the consequences of some of the errors which are committed in the charges assessed on the public works of this country.

The writer has recently published a work* in which he has attempted to expose the true principles of trade, and to show the only correct mode of determining the tolls proper to be levied on our great lines of Canals and Railroads. But it has been suggested to him by some intelligent readers of that work, that the method of analysing the subject which he has been compelled to adopt in it, is not the best adapted to the pursuits of the class of readers most likely to be interested in the subject; and that some advantage might be derived from exhibiting, in a popular form, a few of the results

* "An Essay on the Laws of Trade in reference to the works of Public Improvement in the United States."

which were there obtained by a different process. This essay is intended to subserve that purpose; and to show that the principles on which all the tariffs in the country are based, are unsound, and lead, in their application, to oppressive injustice to a portion of the community, and to great loss of trade and revenue to the improvements.

§ 1. *Of the Importance of the Subject.*

1. There are no questions of public policy which are thought to concern so intimately the general and particular interests of the people of this country, as those which relate to their internal improvements. The consideration of this subject constitutes the greatest part of the legislation of nearly all the States in the Union, and the employment of the privileges sanctioned by the law, constitutes a prominent portion of the efforts of individual enterprise. There are now completed and in use in the country more than three thousand miles of railroads, and not less than three thousand miles of canals, the construction of which has occasioned an actual expenditure of probably $150,000,000, and for which loans have been incurred by the State governments or incorporated companies, to nearly an equal amount.

This enormous investment of capital is by some viewed as alarming; and might, indeed, appear so, when it is considered that a draft of some eight millions of dollars will be annually made on the country for the payment of the interest on this sum, and that the principal itself, in the brief space of twenty years, may possibly have to be refunded. On the other hand, there are sanguine advocates of improvements, who look to the revenue to be derived from the works themselves, consequent on the rapid growth and progressively increasing productiveness of the country, as offering an ample guaranty for the prompt payment of the interest, and the due liquidation of the principal, of the debt.

It is not the intention now to discuss this momentous question, or to endeavour to ascertain which of these hypotheses approaches nearest the truth. Both are but surmises, advanced as the result of a hasty glance at the facts, or possibly based on no safer evidence than the prepossessions, or mere conjectures, of the parties. They are wanting in that detail, that exhibition of statistical information, without which it is impossible to generalize with security.

Doubtless many of the works of the country will possess abundant means to sustain their credit; and among so many enterprises, it is equally probable that some have been undertaken which will fall very far short of the expectations of their patrons.

2. But, whatever may be the general ability of these immense lines of improvements, it is certain that the success and profitableness of those which are now progressing under the fairest auspices, are not so well established but that it ought to be an object of deep solicitude with their proprietors to find the means of increasing their productiveness. To every State that has embarked in a career of internal improvement, and to every individual who has invested his property in such stock, it is an interesting question to ascertain the most efficient means of equalizing the charges on the trade, and increasing the revenue and tonnage of the line.

The public improvements of Pennsylvania are sinking that commonwealth in debt about *a million and a half per annum*—or, in other words, the interest on the loans incurred for their construction, added to the annual charges for repairs and superintendence, exceeds the gross revenue of the works from one to two millions of dollars per annum.

Those of Ohio, and many of those constructed by great incorporated joint stock companies, exhibit balances scarcely less unsatisfactory: and, although these unpropitious results cannot be fairly adduced as evidences of the impolicy of the undertakings, they are facts which may be legitimately used in evidence of the necessity of inquiring into the correctness of the principles of their management. Many of them are now regarded as partial failures, and have involved the community in great pecuniary difficulty. Possibly a careful investigation of the principles on which their tariffs have been established, may lead to the conviction that there is some radical error of administration which may be advantageously corrected.

No more fitting season can be selected for such an investigation than the present. The system of public improvement is now prostrated throughout the country for want of the means necessary for the extension of the works. Those who have been engaged in their execution, may therefore take time to consider by what mode the tax with which they load their constructors may be lightened, or the revenue they pay may be augmented.

3. It is not less important that the charges adopted on the works should be those which would render them most productive to the stockholders, or to the commonwealth as a proprietor, than that they should be reconcilable with principles of justice. In levying a tax for purposes of revenue on any portion of the property of the public, it has been an object of legislation in all times, to make the nearest possible approach to equity in its distribution. The tolls charged on the works of the commonwealth are intended for revenue, and they should be so adjusted, if such an adjustment be practicable, as to produce the greatest possible revenue with the least inequality in the taxation.

At the same time it is essential to have due regard to the cultivation of the trade, which is the primary object of the improvements—a condition which must be reconciled with those above stated—of drawing the greatest possible revenue from the transportation of the produce of the country, and an adherence to principles of equity in the distribution of the tax.

This may appear to be a complicated problem, the solution of which, however desirable in itself, can scarcely be regarded as attainable in practice.

I shall endeavour, however, to show by a few evident propositions, both that the principles by which these charges are now assessed on all our great lines, are such as operate unjustly upon a large portion of the country; are such as in great measure defeat this primary object of the improvement,—that of inviting the distant trade to a market—and such as reduce the revenue far below the limit belonging to a more just and more judicious tariff; and, at the same time, that an attention to the true laws of trade will render the avoidance of these errors exceedingly easy.

2. *Of the Incorrectness of the Principles on which Tolls are at present assessed.*

4. To be able to appreciate the necessity of a departure from the principles on which the present charges for the use of our public works are established, it is essential to examine into the effective operation of the scale now in use. To render the view which I design to take as little complicated as possible, it may be confined for the present to one of the principal divisions of the trade of the country. For, in treating of the laws of trade, it is found convenient to divide the commerce of the line into two principal classes; in the first of which is included all those commodities which will bear but a

limited charge for their transportation, and which, if taxed beyond that limit, will be excluded from the line and from market. This division usually consists of stone, coal, lumber, ore, lime, and many agricultural productions. Indeed it embraces all articles which will seek a market along the line in question, and no other; and in this respect is to be distinguished from that division of the trade which consists of more valuable commodities, and which, if not accommodated on one line, will find a passage by the route of a rival work.

Our present investigation will be confined to the first of these divisions.

5. The charges which are levied on this trade consist of what are usually termed *freight* and *toll*. If the work be a canal, by freight is understood the charge of the carrier, and by toll that of the state or corporation owning the work. In the management of railroads, it is usual for the company to act as carrier on their own line; and to make but one charge, which is called *toll*, for both objects. In this essay I shall make a somewhat different application of these terms, and designate by *freight*, in either case, every expense actually incurred in the carriage of the commodity, and by *toll*, the clear profit on its transportation. So that if the carrier, or transporting company, charge seven mills per mile for the carriage of one ton of any article, and the cost of repairs and superintendence of the line due to the passage of that ton is three mills per mile, I call the *freight* on the article one cent per ton per mile; and any charge, exceeding this three mills, which is assessed by the state or company, is what I denominate their *toll*.

6. In nearly every tariff of toll adopted in this country, the charge on every article is proportional to the distance it is transported on the line. The *toll* is some fixed amount per ton per mile. This scale of taxation, I contend, is improper and unjust.

To examine the question, let us suppose the article to be lumber, of which the market value, at the point to which it is sent, is $10 per ton. Let us also assume that the cost of producing this article, or preparing it for shipping on the canal, is $6 per ton. It is then most obvious that if the charge for transportation on this commodity exceed $4 per ton it will be wholly excluded from the line; for then the cost of carriage added to the cost of production would exceed the market value of the article, and there could be no profit to remunerate the producer. But if the charge be less than $4 there will be a certain profit, and the article will be found to seek the market.

If now, this lumber is carried a space of *one hundred miles* to its mart, and the charge for *freight* is one cent per ton per mile, the freight for that distance will obviously be $1, and there will remain a balance of $3 for the extreme limit which the article will bear to be charged for toll. The toll levied by the state, at one cent per ton per mile, will be $1, or one-third the amount, which the article could in this case sustain.

Let us next suppose that similar lumber comes upon the line at a distance of *three hundred miles* from the same mart. The charge for *freight* would now be $3, and there would consequently be a residue of only $1 on which the state might levy for toll. The commodity could bear no more than $1 —since that sum added to the $3 freight would be $4, or the difference between the cost of producing the lumber and its price in market. But, by the principle of taxation usually adopted, the toll assessed at one cent per ton per mile, would here be $3, or three times as much as the article would bear. In other words, *at the distance of one hundred miles from the mart, in the usual tariffs, a commodity is charged one dollar where it might bear a*

charge of three, and at three hundred miles it is charged three dollars where it could bear but one.

7. Does it need any argument to prove that a scale producing such results is neither compatible with principles of equity or good economy? Is it not manifestly unjust to charge the man who is situated three hundred miles from market three times as much as he can afford to pay, while the man at one hundred miles can afford to pay three times as much as he is charged? Is it not any thing but good economy to tax all the trade in this article beyond two hundred miles so heavily that it is totally driven from the line, when, if the tolls were differently assessed, it might be invited, and made to pay a respectable revenue to the state? And is not the primary object of the work defeated by the adoption of a tariff that excludes those commodities from it which it was especially intended to draw to market—an effect which is accompanied by a direct sacrifice of trade, revenue, and even justice?

8. I think it can scarcely need more than this plain exposition to make clear to any reflecting mind that some of the charges on the public works of this country need revision: that they are based on principles which are unsound, and at once do injury to the proprietors of the work, and injustice to a large portion of the public. The commonwealth, as the constructor and owner of the improvement, is a sufferer in the loss of the trade that is excluded, and the revenue that might be derived from it; the citizens of the emporium which is the mart of the line, suffer from the contraction of their business in consequence of the exclusion of the articles in which they traffic; and the country traversed by the improvement, and taxed, perhaps, for its construction, suffers from its inability to share the benefits which the work was designed to confer.

§ 3. *Further evidence of the loss of Trade consequent on uniform Charges.*

9. To render more palpable the fact that a charge for toll proportioned directly to the distance will cause the exclusion of a certain amount of tonnage, without conferring any compensating advantage, we will consider the subject with the aid of a diagram. (See Fig. 1.)

Let M in the figure be the position of the mart, and M L the line of the improvement: and let us assume, as before, that the commodity will be capable of sustaining a charge of $4 per ton for its transportation; that the *toll* is one cent per ton per mile, the *freight* likewise one cent, and the cost of carriage on the lateral roads by which the tonnage is brought to the work, is ten cents per ton per mile.

The distance M *n* from which this commodity can be brought to the mart at M on the lateral roads *n* M, *n* M, will then be forty miles; and the distance M P which we can afford to carry it along the improvement, at an aggregate charge of two cents per ton per mile, will of course be two hundred miles. The area of country, therefore, which will supply trade to the line, will be represented by the triangle *n* P *n*, having a base *n n* of eighty miles, and a height M P of two hundred miles.

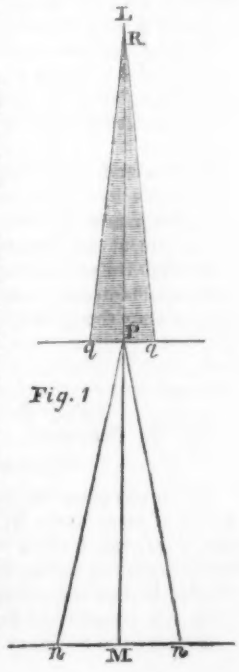


Fig. 1

10. Now, it is apparent that the line will receive no tonnage of this article, from beyond the point P; and therefore, that if the trade were permitted to come free of toll from beyond that point, there would result a certain increase of tonnage, which would be accompanied by no diminution of revenue.

Under such an arrangement of the tariff, the charge for freight from P to M, for produce coming from the country beyond P, would be only $2, and there would consequently be left a balance at P of $2 out of the limit of $4 which the article could sustain, to bear the cost of its carriage along the lateral roads to the improvement, and down the improvement to the mart.

This balance will be sufficient to pay the cost of transportation on the lateral road from *q* to P, a distance of twenty miles, at ten cents per ton per mile; and the charge for freight along the improvement, from R to P, a distance of two hundred miles, at one cent per ton per mile. It would, therefore, be within the ability of the state or company, in this example, to extend the benefits of the improvement four hundred miles into the interior, instead of two hundred, and increase the tonnage of the line, with all the incidental advantages, *fifty per cent.*, without sustaining any loss of revenue.

11. It is far from my intention here to advocate a tariff arranged with a view to this effect; but merely to show what is lost by those which are commonly adopted. Instead of draining only the country contained in the triangle *n* P *n*, which will supply the trade where the charge for toll is one cent, and freight one cent, by charging toll from M to P, and permitting all articles brought from beyond the angle P to pass free of toll, the shaded triangle *q* R *q* in the figure, will be added to the area using the work and supplying its tonnage. The value of the improvement to the country will be increased one half; the trade of the city at M will likewise be increased one half, and the value of the property of the commonwealth, as far as it is dependent on the activity of the work, will be proportionally augmented.

But such an arrangement would effect injustice, and could not therefore receive the sanction of a government administered in a due regard to the first principles of its existence—the equal protection of the citizens, and an equitable distribution of the benefits which its constitution was intended to confer.

Such a tariff would augment the tonnage of the line—but it would produce that result by taxing the citizen immediately at P $4, and excluding him from the work; and the neighbour immediately beyond P but $2, and inviting him at the expense of a premium.

Besides these objections to this arrangement, there exists the additional and important one, that it would not fulfil another imperative condition—that of obtaining the greatest revenue from the trade.

TO BE CONTINUED.

FOR THE JOURNAL OF THE FRANKLIN INSTITUTE.

On the Prevention of Accidents, by Fire, on Board of Steamboats.

By ITHAMAR A. BEARD, *Civil Engineer.*

Much has been written and published on the prevention of accidents on board of steamboats by the bursting of boilers or the collapsing of flues; and I fear much more will be required to prevent all accidents and fatal catastrophes in boats, which, in too many instances I believe, to arise from a want of due caution on the part of those whose business it is to guard the lives and property of the public, confided to their skill and watchful care.

Besides the ordinary class of accidents, there is another class of which

we have on record several accounts within a few years, and one very recently, of a still more awful and distressing nature. I have reference to the burning of a boat at sea, where the passengers and crew have no alternative, but must either burn or drown.

I do not now recollect having read any efficient mode proposed for extinguishing fire on board a boat, nor any other theory recommended than the ordinary mode with buckets and a fire engine.

Believing that there is always ready at hand and available, with proper fixtures, in every steamboat, an agent much more efficient than water and an ordinary engine to extinguish fire, I deem it a duty to make the suggestion, that others who may be disposed, and have better means than I can command, may try experiments upon it, and test the utility of the theory.

From the few imperfect experiments my means have permitted, I am of opinion, that steam is far preferable to water to extinguish fire. For steam can be made to enter every apartment, birth, and crevice, even where water would not possibly be thrown, and being lighter than air it keeps the space filled instead of falling to the bottom as water would do, and can be as effective on the under side of a ceiling, deck, or floor as it would be on the top, and even more so.

The first that I ever noticed of the effect of steam upon flame was several years since, by carrying a lighted lamp into a room in a dye-house that was filled with steam, and the light was instantly extinguished.

Again, when the steam was issuing from the nose of a teakettle, I have taken a bright coal of fire and held it in the steam, and the fire was quenched in as short a time as if it had been immersed in water, and as effectually through the coal.

Now if the theory be true (which, I confess, needs further experiment and stronger proof) a comparatively trifling expense may furnish every steamboat with certain and available means of readily extinguishing a fire, if it should take in the woodwork of the boat, or in the freight, either on or under deck.

I would propose the following mode of operation. Let a pipe, say a gas pipe, or any other that shall be of strength sufficient to bear the pressure of the steam, be connected with the boiler, either directly or indirectly, at pleasure, and be carried to every apartment in the boat. And in as many places as may be thought expedient, insert stopcocks of such construction that they can be readily and easily opened at any time and by any person.

In case of a fire in any apartment the occupants would of course leave the apartment as soon as possible, and when the apartment should be vacated, let the stopcocks be opened, and force in as much steam as would be practicable. Under deck, and in a close apartment, it would have a double advantage over water, for it would, in a great measure, exclude the air from feeding the flame, at the same time it produced an effect by its moisture, but the greatest effect would undoubtedly be produced by the excluding of the air.

In addition to the foregoing, I would attach pipes and carry them on each side of the engine, fore and aft, upon the deck some thirty or forty feet, and at the terminations I would affix "gooseneck joints," and to these attach several lengths of pipe in joints of six or eight feet, and then another "gooseneck" and to this attach a directing and discharging pipe of about the same length as the other joints, all the connexions to be made with screw joints, or couplings.

The two goosenecks would enable the man having charge of the pipe to convey and use the steam on any part of the deck, with nearly as great facility as water would be conveyed and used with a hose: and, if necessary, any number of goosenecks may be used.

To enable the men to handle and use the pipes without burning their hands, let some two or three feet of each joint of pipe be incased in, or near, the middle, with a tin or sheet brass cylinder (brass is preferable,) one inch, more or less, at pleasure, greater than the steam pipes, and fill the space between the two pipes with pulverized charcoal, pipe clay, or soapstone dust, and outside of the exterior cylinder wind on some two or three thicknesses of woolen cloth, and this will fully protect the hands of the men in moving and directing the pipes.

It is thought that this mode of extinguishing a fire in a boat may be more effective than a fire engine, and may always be available at the moment it may be needed, whereas, with a fire engine, there must always be a delay, and frequently, perhaps generally, much difficulty in supplying it with water and in getting it into action, and more difficulty, in the terror and confusion in getting hands to work it; and these unavoidable difficulties, it is presumed, would, in most instances, let the fire get such headway that no power on earth could arrest its progress; and inevitable destruction is the consequence.

In any situation, a single bucket of water when a fire first takes, is of more effect than an ocean after the building is enveloped in flames. And on board a boat, especially, it is necessary to stop the progress of a fire immediately and with the least possible delay, for if the wind did not blow, the motion of the boat would produce a current of air sufficient to kindle a fire rapidly.

In general it would be favourable, in case of a fire, to run the boat directly before the wind, and this would, in a measure, neutralize its effect; but circumstances might alter the case in this respect.

As too much precaution, to preserve and render life and property safe, cannot be used, whether philantrophic motives, or those arising from self interest on the part of steamboat owners, be consulted, every boat should be well and constantly furnished with every possible means of safety or escape in case of accidents of any kind.

For one such catastrophe as that of the Lexington, is enough to deter thousands who would otherwise patronize steamboats with perfect confidence, from risking their lives and property on board a boat, for years. And unless some sure measures can be adopted and put in general use to render safety more certain to the public than has been the case, in very many instances, every year since steam got into general use as a motive power; this mode of conveyance and travelling ought to be totally abandoned.

But it is thought, by not a few, that most of the accidents are chargeable, in a very great degree, to neglect of duty and proper precaution, and to the want of preventive means on the part of those who own, as well as of those whose business it is to manage steamboats, and that it is fully practicable to render them as safe as any other mode of travelling.

I am not fully confident that there is any value in my hints respecting extinguishing fire by steam; but trust the reader will not impugn my motives even if he shall feel inclined to reject my theory as worthless.

If it have no other value than to draw from other and more ingenious minds some further and better views on the subject that may ultimately lead to the adoption of better modes to ensure safety, I shall feel fully compensated and highly gratified.

FOR THE JOURNAL OF THE FRANKLIN INSTITUTE.

Description of an improvement on the Bridge patented by ITHEIL TOWNE, *Esq., the term of which patent has expired. By* ITHAMAR A. BEARD, *Civil Engineer.*

Elevation.

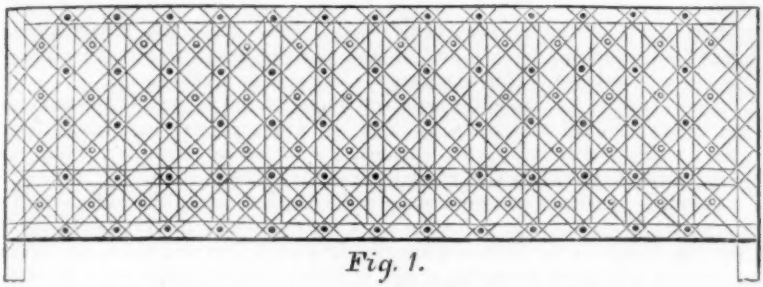
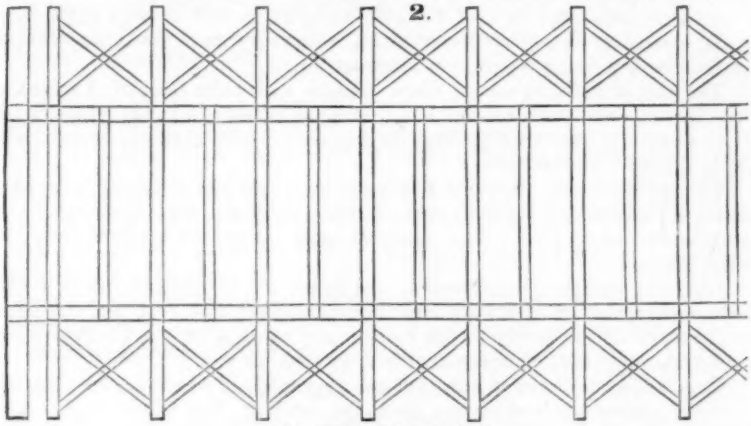
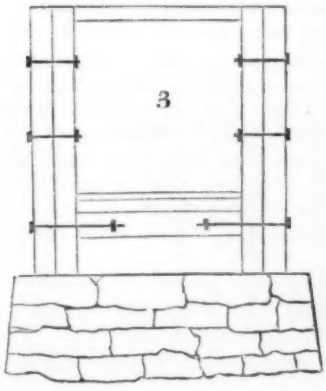


Fig. 1.

The Improvement consists in the Upright Plank, and the Iron Bolts.
The Bolts are marked with a full dot (.) The Treenails marked with an open dot (○)



Scale, twelve feet to an inch.



In 1836 I was requested to advise the best construction for a bridge to be erected over a branch of the Androscoggin river, at Brunswick, Maine, from the main land to an island.

Accordingly, I recommended Mr. Towne's bridge; and in making a model for the purpose, it occurred to me that a great addition might be made to the strength and durability of the bridge by the addition of a pair of upright planks (one on each side of the × work;) over one half the intersections, these planks to stand perpendicular like posts, and the treenails or bolts to pass through and connect the × work and the uprights at each crossing.

My object and intentions were to prevent, in the greatest possible degree, the depression of the bridge, and, on trial, I found my expectations fully realized.

This bridge is 101 feet long, in a single span, and is built with a single travel only, twelve feet wide in the clear, and the travel of the bridge is arched, or crowned, sixteen inches in the centre above a level with the ends.

For the better convenience of drafting I have made the accompanying plans level from end to end, and in fact, in a bridge of this structure I cannot see that any benefit or advantage is derived by arching.

In this bridge, instead of the ordinary treenails, the principal intersections are firmly secured with bolts made of one and a quarter inch round iron, (Bank's best,) with cast iron washers, six inches in diameter, under the heads and nuts; a single bolt being used at each intersection.

There is a vast advantage in using the bolts, with heads and nuts, over the treenails, for, it not only holds the work together more firmly at first, but it likewise furnishes the means of keeping it always firm and close, for as the woodwork shrinks by seasoning or age, as is invariably the case, even if tolerably seasoned when worked, by turning up the nuts upon the screws occasionally, it may always be kept as compact as when first built.

Another advantage is, that the bolts need not be half so large as the treenails, and fewer in number are required, which very much saves the strength of the plank through which they are inserted.

The cost of building one of these bridges with bolts instead of treenails will be somewhat greater, but for a term of twenty or thirty years, I am fully of opinion that a bridge may be supported with less expense than if built wholly with treenails.

The bridge herein described was built by Capt. James Derby who now owns the Island and Mills thereon, and the work was most thoroughly put together in every part. The using of bolts instead of treenails was his suggestion.

After the bridge was completed, and before the trussels on which it was built were taken out, I set my levelling instrument and took the elevation of the travel of the bridge in the centre, and again after the trussels were removed, and it settled seven-tenths of an inch only.

This bridge has been in constant use ever since it was built, for teaming over with heavy loads of lumber from the mills on the Island, and it now stands as perfectly firm, true, and straight as it did when first completed.

To give a more clear idea of the cost of a bridge so constructed, I will insert the number of pieces and dimensions of all the materials of which this bridge is constructed, and also the cost for materials and labour as nearly as I can obtain them.

Timber and Plank.								Feet.
8	Posts	20	feet	long,	16	by	16	inches.	3413
2	Headsticks	18	"		20	"	20	"	1200
120	Planks for × work	21	"		10	"	3	"	6300
116	Do. Uprights	12	"		8	"	4	"	3712
20	Ranges of Stretchers	101	"		9	"	3	"	4545
15	Crossills	26	"		9	"	6	"	1755
15	Do.	16	"		9	"	6	"	1080
11	Cross Caps	14	"		8	"	8	"	821
22	Braces	16	"		6	"	4	"	704

60 Do. 7 feet long, 6 by 4 inches. 840
Planking of the travel, 101 feet long 12 feet wide 3 inches thick 3636

Plank and Timber, in board measure, 28,006

Making allowance for waste, say 30,000 feet, worth here, at that time, $15 per thousand.

All the timber of this bridge is white pine.

The travel of this bridge is laid with the length of the plank lengthwise of the bridge. I do not think the plank will be so durable laid in this way as they would be if laid crosswise of the bridge, especially for heavy loads, and if planked crosswise a set of stringers must be laid on the crossills; say 5 stringers, 101 feet long 9 by 6 inches—2272 feet.

Taking the lumber of this bridge as it is 30,000, *a* $15 per thousand $450 00
632 cast iron washers, 3¼ pounds each, 2054 pounds *a* 5 cts. 102 70
304 Bolts 24 inches long } weighing 2600 pounds.
12 " 34 " }
Estimation for heads, nuts and waste 400 "

Say 3000 *a* 10 c. including making 300 00
The labour was done by hands hired by the day, at an average of about $1 50 each per day, board included, and cost as nearly as can be estimated, about 375 00

$1227 70

Equal to twelve dollars a foot in length very nearly.

It is estimated that a bridge with two travels, fifteen feet wide each, with two sidewalks outside of the × work, and without a roof, may be built for twenty dollars a foot in length; timber and labour being at the same value as above rated.

To this must be added the cost of abutments and piers and of a roof if the bridge is to be covered.

There are no bridges in this section of country that stand so well and so durable as the "Town Bridge," and it is getting into general use.

Brunswick, Maine, March 27, 1840.

Hydraulic Works at Algiers. By M. Poirel, *Engineer of Bridges and Roads.*

[*Translated from the Annales des Ponts et Chausseés by W. H. Emory, Jr., U. S. Topl. Engrs.*]

The port of Algiers was established as far back as the year 1530, by Cheredin, brother of Barbarossa. Having made himself master of a little island, in front of the city, which the Spaniards had fortified, he resolved, in order to secure it, and at the same time to make, at Algiers, a harbour that would afford protection from the winds and from the swell of the sea, to unite it to the town by means of a jetty. This is called the Cheredin jetty, and is two hundred and twenty-three yards long and one hundred and twenty-seven yards wide. Its direction is nearly east north-east; or west south-west.

Besides the Cheredin jetty, another has been built on the prolongation of the island, which protects the harbour from easterly winds, and is called the mole. It is one hundred and seventy-four yards long, and forty-five yards in its greatest width. This mole runs north-east and south-west. These two

jetties with the little mole on which the Lazaretto stands form the boundary of the basin. It contains forty thousand seven hundred and twenty-two superficial yards, and can float sixty vessels, of which about thirty, may be vessels of three hundred tons, and some few, eight hundred tons. Vessels of a larger class anchor outside the basin. The greatest depth of water is sixteen and a half feet; but this may be increased by dredging. The Cheredin jetty and the mole were found in a state of complete dilapidation when Algiers fell into the hands of the French. These two works constructed of loose stone, (sometimes called rip-rap in the United States,) were levelled to their base. The Deys were in the habit every year of having the stones replaced which were carried away in the winter by the sea.

Laugier de Tassy, one of the most faithful historians of the Algerine regency, who resided there in 1727, says:—

"The great mole (the Cheredin jetty,) being entirely exposed to the north, to prevent it from being carried away by the furious swells of the sea, which roll up the sand bank, stretching along this mole and out into the sea, they were obliged to keep the slaves of the beylick employed the whole year carrying hard stones from a place near point Pescade, to put them along the mole. The sea soon carried away the stones thus deposited, but care was always taken that they should be replaced."

Large magazines of military supplies are placed on the Cheredin jetty and it naturally claimed the first attention of government.

The preservation of these magazines required that the loose stone upon which they rested, at the base of the jetty, should be secured.

This undertaking was confided to M. Noel, the engineer, in charge of the hydraulic works at Toulon, from which he was temporarily relieved.

He rebuilt the entire body of the jetty to a height of sixteen and a half feet above the water, with a thickness of six and a half feet. The new masonry is of the very best kind and possesses great solidity; unfortunately the insufficiency of funds placed at the disposal of the engineer and his limited time did not permit him to turn his attention to the foundation of the jetty which will soon require considerable repair.

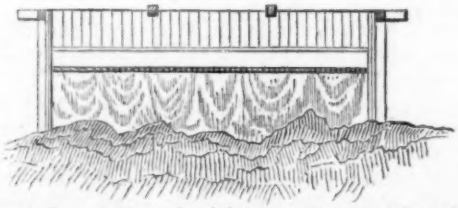
The extremity of the mole, called the chop, in which the sea made a large breach, was repaired in 1831, but the new masonry being built upon the fragments which the action of the sea had brought down, was entirely destroyed by the first storm in the winter of 1832. All the repairs made to the top of the work were necessarily liable to the same catastrophe, as the base upon which they rested was insecure. It became necessary, therefore, before proceeding farther, to reconstruct the base permanently and durably.

The locality did not permit the engineer's resorting to the ordinary means of establishing a foundation by throwing over loose stones, (rip-rap.) The shore to the west, where the quarries are, has not a single creek or harbour where a vessel could load; it is open to the ocean and skirted by a reef of rocks which make the landing dangerous even in a calm. The transportation of blocks of stone could only be effected by carriages, a tedious and difficult operation with masses, which, to resist the action of the waves, should measure at least four cubic yards. Besides which it would have been necessary to carry these blocks through the most frequented and populous part of the city, very much to the inconvenience of the inhabitants passing to and fro. Another difficulty presented inself, even if the obstacles to an easy transportation had been overcome. To give sufficient stability to the work at the end of the mole, a long slope of at least one in ten was necessary, which would have entirely obstructed the navigation, as the entrance to the basin was already very narrow, being

only one hundred and thirty-four yards wide, measuring from the end of the mole on which the Lazaretto stands, to that of the work in question.

Under these circumstances, the engineer was obliged to resort to other expedients, and he was thus led to form and execute a new plan for establishing foundations at sea, which five years experience of the works at Algiers has proved to be, according to all accounts, superior to all those which have heretofore been put in practice and particularly to those made of rip-rap work; a method much approved of since the construction of the Cherbourg and Plymouth breakwaters, the two most important maritime works executed in modern times.

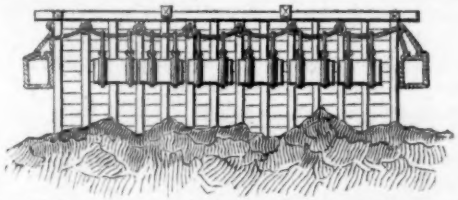
The principle feature of this plan is the use of blocks made of béton. These blocks are of two kinds; one being constructed in the water at the place it is intended to occupy, the other made on shore and launched.



The first is made by pouring the béton into cases without bottoms, sunk on the place where the block is to rest. The frames of these cases as shown in the annexed cut, are made by putting together pieces of scantling, in a rectangular form, and the sides are made by nailing to this frame two courses of plank placed at right angles to each other. The lower edges of the cases are cut out to fit the profile of the surface on which they are to rest. They are lined with tarred cloth, throughout the whole extent of the inside up to the level of the water. The cloth at the bottom is allowed sufficient fullness to accomodate itself to the inequalities of the ground. The cases are thus, in fact, converted into cloth sacks, the sides of which are strengthened by the timber work on which they are stretched and fastened. The cloth sacks enable the mass of béton to accommodate itself perfectly to the surface which receives it, the inequalities of which serve to bind together the rock forming the bottom, and the béton. This is a great advantage in the use of these cases, for with the flat bottomed ones generally used, it is necessary to level the surface to be built upon, which is a difficult and uncertain operation.

The cloth bottomed cases are built upon stocks, launched and floated to the place they are to occupy. They are then sunk by means of small wooden boxes, one foot square, filled with cannon balls or pig-iron strung entirely around on the outside of the case, about one foot and a half from the top, by means of a cable passing through iron rings fixed in the uprights.

The arrangements for sinking the cases is shown in the annexed figure.



A similar use of béton was made by the Italians to prevent the disinte-

gration of masonry immersed in water. They filled, with béton, bags similar to those used in fortification for making earth defences, and placed them compactly, one upon the other, and in such a manner as to fill up the inequalities of the surface on which they rested. The cement which oozed out through the interstices of the cloth, bound the little rolls of béton together and soon formed a very compact and durable mass. The cloth between the joints rotted and disappeared in a few years. On one occasion, they filled a much larger sack with béton than those above described, and threw it into the sea in stormy weather; some days after the storm had subsided they found this block very hard and strong. From the result of this experiment it was natural that the adoption of very large blocks of béton should be thought of, but the difficulty consisted in making bags of those dimensions which would not burst, and fixing them in position, while being filled with béton.

When the case is moored, the béton is lowered and deposited in it by means of a trough, which has a vertical and semi-rotary motion communicated to it by a cylinder worked at each end by a crank. This trough which contains a little more than a cubic yard, gives the advantage of putting in the case a large quantity at a time. The operation is thus made more rapid and there are fewer seams.

The béton blocks made on shore are moulded in cases consisting of four sides made of thick planks and lined on the inside with another course of plank jointed together at the bottom and removable at pleasure. The bottom rests upon two large sills connected transversely, forming an inclined plane which terminates at the point where the block is to be launched. These cases like the others, are entirely empty and without shores. When they are filled with béton, and it becomes sufficiently hard, the sides are taken off and the block thus stripped is launched into the sea.

The mortar used in the large cases with cloth bottoms, is formed of one part fat lime and two parts of Italian puzzolana; that used for blocks on shore is composed of puzzolana and sand in equal proportions.

The lime should be made from the grey transition limestone, fine grained and very hard; slaked in the ordinary way, and reduced to the consistency of thick paste, it absorbs two and a half times its weight of water. Its bulk is increased in the proportion of 1 to 1.8.

The puzzolana is the same as that used along the Mediterranean coast in the formation of hydraulic mortars. It is to be found in the neighbourhood of Rome. The best comes from Saint Paul's cave, near the church of that name. This puzzolana is brought by wagons to the Tiber, and thence by batteaux to Civita Vecchiá, whence it is exported. It is sent abroad in the natural condition in which it is found, the pieces varying in size from that of an egg to the smallest grain of sand. M. Jullien, the engineer, found by experiment that the very finest grains were the only ones that could be used with effect in hydraulic mortars, and that when it was used in grains as large, for example, as the largest grains of sea sand, it was as ineffectual as the sea sand itself. From this it appears to be necessary that the finest grained puzzolana alone should be used in hydraulic works; and as its efficacy, and quickness in hardening are in proportion to the fineness, too much pains cannot be taken to pulverize it.

Acting on this principle, the puzzolana brought from Italy to Africa for the work on the mole was sifted at Algiers before being used. One half, forming the residue, was ground in a mortar mill and sifted again, leaving a residue of one tenth.

That ground and sifted was of a quality inferior to that furnished by the

first sifting. The price of the puzzolana delivered at the work was thirty-six francs per cubic yard, and the cost of sifting, grinding, &c., twelve francs, making the total cost forty-eight francs.

The cost of labour at Algiers, independently of the inferior quality of the puzzolana obtained by trituration, and the consequent increase of expense, made it desirable that it should be sifted at Rome and the refuse left there. The soil on which this city and its environs stand, is composed of this material, and is of course very cheap. The only difference in the price would therefore arise from the cost of sifting, which could be more than balanced by the freight saved in leaving the refuse.

Influenced by these considerations, the author, on the requisition of the Governor General was authorized by the Secretary of War to repair to Rome and superintend in person, the details of the operation. He there fixed up a number of strong bolting cloths pierced with small rectangular holes. The price of sifting one cubic yard of puzzolana with labour hired of the pontifical government, was about twenty cents.

The contractor who has leased from the Roman government, the monopoly in the puzzolana trade, regarding the project as impracticable, asked an exorbitant price for taking charge of it, but as soon as he discovered it was both easy and cheap, he came forward and offered for the future to send none but the sifted puzzolana to Algiers. It was delivered there in 1837, in this state, for forty-two francs the cubic yard, and could, without doubt, be delivered for forty francs. By adding one half sand, quite as good a commodity as the rough puzzolana is produced, and you get for twenty francs what formerly cost thirty-nine. At this price this material is likely to supersede all the hydraulic lime and artificial cements made at the different localities. It is easier worked, and the quality is superior or at least equal.

Algiers is not the only place where this measure can be adopted advantageously; it can be practised with advantage on the whole Mediterranean coast and wherever the puzzolana of Italy is used. The engineers of Toulon and Marseilles have already made arrangements for the importation of the sifted puzzolana, and there is little doubt but that it will become an extensive article of traffic.

The mortar is made with one part lime in paste, and two parts puzzolana. If the puzzolana is in the rough state the mortar becomes hard in four days and resists the Vicat rod; if it is sifted through the bolting cloths it will become hard in two days, and if the puzzolana is sifted through a fine hair sieve, it will become hard in twenty-four hours.

It takes six days for mortar to become hard, which is made of one part lime, one of bolted puzzolana and one of sand.

Béton is composed of one part mortar and two of stones broken to the size of from one to two inches,* making two parts of béton.

A cubic metre (35.317 cubic feet) of béton weighs 5886 pounds. It acquires in twenty-four hours, sufficient cohesion to withstand the shock of a heavy sea without disintegration. In November 1836, a block containing two hundred and fifty cubic yards, which had been immersed only thirty-six hours was stripped of its enclosure, and resisted the action of one of the most violent storms. M. Fénéon, a mining engineer, then at Algiers, was an eye witness of this remarkable fact.

The blocks made in the cases with cloth bottoms, measure generally from

* Whether cubic or superficial measure, is not stated. Tr.

one hundred and eighty to two hundred and fifty cubic yards; those made on shore, from fifteen to sixty cubic yards. When constructing the mole at Algiers, they placed first a set of the large blocks, and then, in advance of them, to protect their bases, they placed a number of the second size. The large cases serve as a platform from which to launch the small blocks. The two lines of blocks are bound together at intervals by large blocks of béton, and these intervals are filled by stone measuring from five to eight cubic yards.

The following is an estimate of quantities and labour for a béton block, of thirty-six cubic yards, using mortar made of lime, sand and puzzolana:

36 cubic yards of Broken stone.
12 " " Puzzolana.
12 " " Lime in paste.
12 " " Sand.
1 day's labour for a master workman.
3 " " three labourers.

The cases used cost about one hundred dollars, and one will answer for twenty blocks.

The whole cost of making and laying this béton at Algiers is about five dollars and seventy cents the cubic yard.

Estimate of quantities and labour for a béton block of one hundred and eighty-two cubic yards, sunk in a case with a tarred cloth bottom, caulked, using mortar made of lime and puzzolana:

182 cubic yards of Broken stone.
91 " " Puzzolana.
45½ " " Lime in paste.
1 master workman three days.
2 labourers for three days.

The construction and moving of the case cost about four hundred dollars; it can also be used twenty times.

The caulking at the angles, the cloth bottom and the removal of the case, cost about one hundred and seventy dollars.

The whole cost of making and laying this béton at Algiers, is estimated to be about eight dollars and seventy-five cents the cubic yard.

Colonel Emry published a work in 1831, containing many purely theoretical views, and at the same time many useful suggestions, in which he set forth, strongly, the inconveniences of the present system of building stone work in the sea, and proposed as a substitute, blocks made of béton.

The blocks that he proposed were also of two kinds, one kind made in the water and the other on shore; the first was to be built in a flat bottomed case, and the other he proposed to transport to the place for immersion; a plan of doubtful success; he proposed, too, that these blocks, which were to be hexagonal prisms, should be laid regularly one upon the other, which we regard as impossible.

During the execution of the new system at Algiers, some engineers thought the success of it very doubtful; but the manner in which the end of the mole stands, puts all doubt to rest. This work projects into the sea towards the quarter whence the winds blow with most violence, and it stands without having sustained the slightest injury from the most furious tempests. Besides other unquestioned advantages presented by the use of béton blocks instead of loose stone, the difficulty is avoided of transporting the stone of the requisite size when the quarries are remote. This consideration amounts

sometimes to an insuperable obstacle to the use of loose stone, while the béton can be used any where.

The Romans drew blocks of stone from Mount Circe to build the port of Anxium, a distance of ten miles; and the pontificial government was obliged to abandon the port of Auzo in consequence of the difficulty of finding a quarry in the neighbourhood, that would furnish proper stone to repair the jetties.

The Italians generally practise a mixed system. They build the foundation of loose stones, even in twenty or thirty feet water, and the top of masonry. The masonry is constructed in staunch cases, floated to the place required, and the workmen, secure from water, erect a wall usually of undressed stone and hydraulic mortar. The cases are thus sunk by degrees until they reach the loose stone. The details of this process are described in Belidor's Hydraulic Architecture, in his description of the manner in which the moles at Nice, Genoa and Naples were constructed.

The defects of this plan are very apparent; the bottom of the case rests upon an uneven and movable surface, and the consequence is, the masonry cracks open in many places. Moles thus constructed are soon destroyed; extensive repairs are required, which make it necessary to be continually throwing in loose stone. This is exemplified in the mole at Genoa, which shelters the harbour from the east winds, the end of which constantly requires repair.

When De Cessart projected his large conical cases, he was on the eve of discovering the simple and ingenious plan just described for establishing foundations; the great error which was committed and which fully explained the difficulty encountered by so skilful an engineer, was in supposing that a wooden structure, however substantially constructed, could resist the action of the sea. Acting on this principle, he filled his cases with small stones to keep them in place; the consequence was that when the action of the sea beat these cases to pieces, the stones fell down and the whole fabric was swept away. De Cessart should have considered the case as simply a temporary enclosure to build masonry in, which would be capable of resisting the force acting against it after the cases were destroyed. If he had taken up this idea, it would probably have led him to the use of béton for filling his cases. Instead of making these cases as substantially as was proposed, it would be sufficient to give them the form of a large cask without a bottom, made with uprights and staves bound together by iron chains instead of hoops, in such manner that the uprights can be taken apart when the case is to be taken up. Another indispensable condition is, that the case should be filled in the shortest possible time. The sea at Algiers is very powerful considering the little range it has; and it would be necessary to make such arrangements that a case made to contain about 1300 cubic yards, should be filled in thirty-six, or forty-eight hours. This might be done by throwing in béton blocks, ready made, at the same time pouring in béton to bind them, by means of cloth funnels fixed to the cases. This suggestion has never been acted upon, but if the intention of making Algiers a military port be carried out, there will be an opportunity of trying it on a large scale, and it is believed with complete success.

Whatever may be the fate of this or other plans for using béton, one thing is certain, that sooner or later, the practice of making foundations at sea with loose stone will be entirely abandoned, and masses of the natural rock so costly in quarrying and transportation, and so insufficient in dimensions, will be replaced by artificial blocks made of béton.

Mechanics' Register.

LIST OF AMERICAN PATENTS WHICH ISSUED IN MARCH, 1839, *With Remarks and Exemplifications by the Editor.*

1. For a *Machine for drying Flour, &c.;* John Balantine and Adam Clark, Zanesville, Muskingum county, Ohio, March 4.

This machine consists mainly of a semi-cylindrical vessel, having a flat top which covers the semi-cylinder; this vessel is to be closed at its ends, but there are to be openings for the admission of steam, which is to pass through it. The flat side is to be placed uppermost, and is to form an inclined plane, that the flour, &c., may descend along it; there are to be ledges at the sides to keep the flour from running off.

The claim is to "the use for drying flour, and other finely divided substances, of a cylindrical segment of any length, and any chord, closed at the ends by caps, and along the chord by a plane, except a passage through the closed segment for the drying agent, as herein described; the drying agent being applied within the closed segment, under the plane, and the flour or other substance to be dried passing along the plane."

Why the claim should be limited to the segment of a cylinder, is not very evident, as it would appear that its upper and lower sides might both be planes, and made similar to the hollow drying shelves, of metal, through which steam has been made to pass, for the drying of powder, and other articles. The only novelty, if novelty it be, is the giving the inclination to the drying apparatus, for the descent of the flour.

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2. For an improvement in the *Manufacture of Hat Bodies*; Hezekiah S. Miller, county of Philadelphia, Pennsylvania, March 5.

The invention consists "in a method by which fur after being carded, picked, or blown, is converted into a continuous web, lap, or sheet, for the purpose of being wound into hat bodies, so as to attain advantageously with fur the same end which has heretofore been attained in relation to wool."

By means of a fan wheel, the fur as it is delivered from a carding, or other suitable machine, is blown through a box, or trough, against a revolving cylinder covered with wire gauze, &c. From this it is taken off in a lap, being compressed by rollers, and is then ready to be wound on a former for making hat bodies. The claims are to "the combination of the fan, oblong box, or spout, and cylinder, for the purpose described; and to the combination of the two aprons operating for the purpose and in the manner described; and also these in combination with the combined fan, spout and cylinder, as described."

The resemblance between this apparatus and what has been before patented, or in use, is very close; we cannot take the time, nor do we deem it necessary to examine this point closely, the patent office having no doubt done this before granting the patent; it is to be presumed, therefore, that there was room for the claims made.

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3. For a machine for *Preparing Brick Mortar;* Oran W. Seely, Sodus, Wayne county, New York, March 5.

This machine consists of a circular trough in which are two sets of wheels the peripheries of which are to roll round upon the clay contained in the circular troughs. The wheels are each to have three or four rims, or treads,

and they are placed upon a horizontal shaft which has a screw cut upon it, which passes through corresponding screws in the hubs of the wheels, by which arrangement the wheels traverse back and forth on the shaft between the periphery and centre of the tub, the shaft moving on a vertical post, rising from the middle of the tub, and the motion of the horizontal shaft being reversed, when one of the wheels arrives at the end of it. At the outsides, and between the divisions of the wheels there are scrapers to remove the clay therefrom. The claim is to "the employment of scrapers, in combination with each set of wheels." This, it will be seen, is rather a meagre claim, but we are in error if it be not still too broad. Wheels fixed precisely in the way described were patented many years since, and, most certainly, scrapers were used to remove the superfluous clay from them. The burning of the office has probably destroyed the evidence of this, but it is still, fully in the recollection of the writer.

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4. For improved *Lightning Rods*, for buildings; Joseph S. Barber, Gloucester, Essex county, Massachusetts, March 5.

This is something of a fantastical lightning conductor, the superiority of which over those in use appears to us to be the creature of imagination. A dome-like shell of copper, or other metal, is to be mounted upon a pole which passes through its centre, and gives to it the appearance of an open umbrella. The part of the pole above the dome is to be furnished with points branching out, as frequently practiced, and the lower edge of the dome is to be fringed with pieces of metal cut in the form of leaves, surrounded with numerous points. The claim is to "a paraboloid, constructed as above described, and its combination with a set of branching wire points, in the manner described, and for the purpose set forth."

Those acquainted with the early history of lightning conductors, know something of the little-endians, and the big-endians, whose differences might probably have been reconciled by the foregoing combination of a semi-globe, with sharp points.

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5. For a machine for *Planting Corn and other seeds;* David S. Rockwell, New Canaan, Fairfield county, Connecticut, March 12.

This appears to be a well arranged machine for accomplishing the intended purpose. It runs upon four wheels, and it is designed to plant two rows at once, at such distance apart as may be desired. Two boxes, called droppers, are attached to the side timbers of the machine, and these side timbers may be removed to a greater or less distance apart. The boxes, or droppers, containing the seed, have slides which are operated upon by the revolution of the wheels, and drop the grain, in quantity and distance, as may be required. The claims refer to the special construction and arrangement of these parts, to an understanding of which the drawings would be required.

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6. For a machine for *Preparing Brick Mortar;* Ansel Teal, Waterloo, Seneca county, New York, March 12.

This the inventor calls an *eccentric Mortar Machine;* and it in part resembles that described in No. 3, in having a circular trough within which the mixing instrument is to roll round, and is to move back and forth, towards and from the centre. Instead of wheels with rims, three rows of spokes are to project out from a revolving hub, placed on the horizontal shaft. The

spokes are to be so set as to tend to move the clay towards the centre of the trough, as the horse moves in one direction, and towards the circumference when moving in the opposite direction. The hub does not traverse back and forth on the shaft as in the first described machine, but there is a rack and catch, denominated a sliding gauge, which are to be managed by the attendant, when its place on the shaft is to be changed.

The claim is to "the sliding gauge, constructed as described, in combination with the hub and shaft, by which the motion of the hub, with its arms or spokes, is regulated, and they are prevented moving from the centre of the pit faster than the operator wishes."

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7. For a machine for *Cutting Shingles;* Ludlam M. Parsons, Castleton, Portland county, Maine, March 12.

A knife is to slide up and down, its ends being attached to a frame which operates like that of a saw frame within fender posts. The stuff as it is fed up to the knife bears against a vibrating pannel, allowing a head and point to be alternately cut from each end of the block. There is a contrivance for drawing the block up, and vibrating it and the pannel, and the claim made is to "the vibrating pannel, in combination with the knife, as described."

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8. For an improvement in the *Rotary Steam Engine;* Roger M. Sherman, Fairfield, Connecticut, March 12.

A patent was obtained by Mr. Sherman, on the 25th of April, 1837, for improvements in the rotary steam engine, of the same general construction with that which is the subject of the present patent. The improvement now claimed is to "the fitting of a cap to a rotary steam engine in the manner, and by the means set forth, so that the steam by its own pressure shall prevent its own escape." The manner of construction proposed is well calculated to attain its object; we, however, see no reason to dissent from the opinion we have so frequently expressed, adverse to the equality of the rotary to the reciprocating engine, as hitherto constructed. The objection to it we consider as too deeply seated to be removed by any device however ingenious, or however effective, in removing a difficulty belonging to its details, as is the case in the instance before us.

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9. For a machine for *Cutting Potatoes,* and other vegetables; Abel Williams, Ashfield, Franklin county, Massachusetts, March 12.

The novelty upon which this patent was claimed is not of a very striking character, the machine being very much like others in prior use, as will be seen by the claim. The potatoes, &c., are to be put into a hopper on the lower end of which there is a traversing slide, carrying the cutting knife for slicing, and small vertical knives for cutting through the slices; the patentee says, "I do not claim to be the inventor of the mode of cutting vegetables by means of a single edged knife attached to a gate, and cutting against a bed, with small knives having their planes and edges at right angles with the plane and edge of the main knife, such having been invented before mine. But what I do claim as my invention, and desire to secure by letters patent, is the combination of two setts of small knives as herein described, with a double edged knife attached to a gate, the whole being constructed and operating substantially as herein described."

10. For a machine for *Cutting Straw*; Charles T. Botts, city of Richmond, Virginia, March 15.

The straw is placed in a trough, and fed up towards one end of it by means of rollers, operating in a known manner. Crossing the cutting end of the trough a conical hub of cast iron revolves, carrying two cutting knives, which, by being placed on the conical hub, have a peculiar drawing motion given to their edges. Parts of the hub are cut away to make suitable seats for the knives.

The claim is to "the giving to the hub upon which the knives are affixed, the form of the frustum of a cone, in the manner, and for the purpose set forth. And it is to be understood, that by this conical form nothing more is intended than that the portion of the revolving hub, or body, to which the knives are attached, shall be so formed, as for their edges to stand in that direction, which shall cause them in their revolution to generate the frustum of a cone."

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11. For a machine for *Cutting Straw*; Thomas Hopper, New Brunswick, Somerset county, New Jersey, March 15.

In this machine there is to be a row of knives placed vertically, at such distance apart as shall correspond with the length to be given to the cut straw. The edges of these knives stand in one plane, and a roller, composed of rings of cast iron placed upon a shaft, revolves so that the peripheries of these rings shall enter the spaces between the blades. There are offsets, or teeth, projecting out from these rings, like the teeth of a saw, say five or six on each ring, and these carry the straw, which is fed on to a sloping board, against the knives, which consequently cut it. The knives are dropped into slots, which hold them in place, and by removing every other knife the length cut will be doubled. If used for corn stalks, the roller and offsets should be larger than for straw. The knives may be like common shoe maker's knives, with the handles removed.

The claim is to "the manner above described of cutting straw, and other vegetable matter, by forcing the same against a row, or series of knives, by means of a cylinder having projections thereon, which, by the aid of grooves pass between the knives or cutters, forcing the material to be cut against them."

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12. For a machine for *Thrashing and cleansing Grain*; Matthew M. McKever, Staunton, Augusta county, Virginia, March 15.

This thrashing machine and cleansing apparatus differs but little in the manner of constructing it, or in its operation, from several others; there was nothing to claim, therefore, but the particular arrangement of the respective parts as made by the patentee. The claim is to "the combination of two fans, and their fixtures, with the thrashing machine in the manner described; to the shoot board, in combination with the straw shaker; to the shaker, and to the brace spike, or tooth, constructed as described." We do not see any thing in the matters claimed worthy of special notice.

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13. For a *Chair for Railroads;* Moncure Robinson, C. E., city of Philadelphia, March 16th.

This invention "consists in providing a chair having a shoulder on one side only, with holes or openings to receive screw bolts, which are to pass also through similar holes or openings in the ends of the rails; the holes or

openings in the rails being sufficiently long to afford the requisite play for expansion and contraction of the rails in all changes of temperature."

Claim.—"What I claim as my invention is the plan of attaching the ends of rails to chairs by screw bolts passing through openings in the rails, leaving open the chair on one side, and giving a shoulder to the opposite side, whereby the rail is thoroughly supported against the lateral action of engines and cars, and at the same time the means are afforded of placing and forcing the rails in line as described."

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14. For improvements in *Many chambered Fire Arms*; Elon B. Butterfield, Brattleborough, Windham county, Vermont, March 16.

The claim made is to a "block, or nut, for filling part of the space occupied by the longer cylinder, and fitting the gun to receive a rifle barrel and a shorter cylinder." The whole object of the patent is to enable the owner of the gun to substitute a rifle barrel for one of a smooth bore, the other parts of the gun remaining as before.

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15. For *Ascending Inclined Planes on Rail Roads*; William F. Ketchum, Buffalo, Erie county, New York, March 20. (See Specification.)

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16. For *Ascending Inclined Planes*, on Rail Roads; Davis H. Dotterer, and Thomas Jackson, Reading, Berks county, Pennsylvania, March 25.

The mode of ascending proposed by the patentees requires the use of a rack rail in the centre of the track. The shaft which carries the cog wheel that gears into the rack, has on its ends two flanched wheels, which run upon the rails when the locomotive is ascending an inclined plane, but are raised from their bearing, by a suitable contrivance, when not so employed, the cog wheel being at the same time disengaged from the rack. The two wheels last spoken of are denominated power wheels, they are smaller than the ordinary driving wheels, and of such diameter as to prevent the teeth of the cog wheel from bottoming in the rack. They are driven by connecting rods from the driving wheels, which then act as fly wheels, being raised above the rails.

Claim.—"The locating of the two wheels, which we have denominated flanched power wheels, in the rear of the locomotive engine, behind the ordinary driving wheels, providing the means of raising and lowering such wheels so as to bring a cog wheel affixed on the centre of the same axle, into gear with a rack rail, and to raise the driving wheels clear of the track, for the purpose of enabling such locomotive with the train attached to it, to ascend inclined planes by the operation of the ordinary power of the engine."

There is considerable skill displayed in the plan devised by these patentees, but we apprehend that the objections to the employment of rack wheels on inclined planes are too serious to admit of their adoption.

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17. For a machine for *Cutting Shingles;* J. Hinman, J. Thatcher, and A. Palmer, Persia, Cattaragus county, New York, March 25.

This invention is said to consist "in making shingles from timber in its natural state by cutting them longitudinal from the bolts, or blocks, of the requisite length for the shingles, by a reciprocating knife, placed obliquely, or at right angles, with the slide, or carriage, to which it is attached, operat-

ing parallel, or nearly so, with the grain of timber,'according to the angle of the knife."

The claims made are to "the carriage, or table, constructed with two movable platforms at the upper side, placed at opposite ends, with their sides depressed as much as to give the requisite thickness and taper to the shingles; the opposite platforms having their opposite sides reversed, in combination with the two edged knife, as set forth."

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18. For a *Smut Machine;* William C. Grimes, York, York county, Pennsylvania, March 25.

This machine consists mainly of two vertical cylinders, the innermost revolving within the outer cylinder, or case, as in many other machines for the same purpose; there is, however, a strong characteristic difference from others in the arrangement of the acting parts; among these is the causing "a current of air to pass upwards between the two cylinders, with a degree of force sufficient to carry off all the foreign matter through an opening left for that purpose in the upper part of the machine, whilst the cleaned grain, from its superior gravity, descends and passes out at the bottom of the apparatus. The claim is to the manner of producing a strong upward current of air; the devices for which would require the drawings, or a more lengthened description than we can afford for their explanation. There are some other claims which are in the same predicament, we therefore dismiss the subject with observing that we have heard a very good character of this machine given by those who have made trial of it.

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19. For a *Thashing and Hulling Machine;* Thomas Elliot, Middletown, Jefferson county, Kentucky, March 26.

This machine is said to be for "thrashing all kinds of small grain, for shelling corn, hulling clover seed, and for cutting straw." As may well be supposed, some parts of the machine must be removed and others substituted for them, to adapt it to the various purposes to which it is be applied. The specification is necessarily one of great length, referring to the respective parts in the drawings. The claims refer to the different devices employed, and we shall therefore omit them, as not aiding in the description. Whether the changes to be made are such as still leave the machine in possession of the character of individuality, may admit of some doubt; the law gives a patent for any new machine; but there have been many cases in which a patent has been refused where such a change was proposed to be made in a machine as would constitute it, essentially, another machine, applicable to a new purpose; such it seems was not the judgment of the office in the case before us.

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20. For a machine for *Shelling Corn;* W. McElroy, Jr., and B. and W. Boon, Greenwich, Warren county, New Jersey, March 30.

This machine is, in its general construction, similar to that first invented and patented for shelling corn; the effect being produced by feeding the corn between a revolving cylinder set with teeth, and a concave which in part surrounds the cylinder. There are, however, some new devices employed, in the particular manner of constructing the concave, and regulating its yielding, so as to adapt itself to ears of different sizes. The concave is denominated a "back," and the claim is to "the mode described of sustaining and regulating the self-acting back, by the combined action of the straps, &c., and the lower spring, or springs."

21. For a *Tailor's Draughting Instrument*; Edward Axford, city of Philadelphia, March 30.

The specification of this patent extends through eleven pages of record, describing the draughting instrument, which contains the ordinary square, with several additional arms, and numerous scales; and this is accompanied by diagrams illustrative of the mode of using the instrument. We freely confess our entire incompetence to undertake the analysis of this matter, which seems to us so recondite, as to belong to the initiated only. We have no doubt, however, respecting the cleverness of the whole matter, from the known character, and handiwork of the patentee.

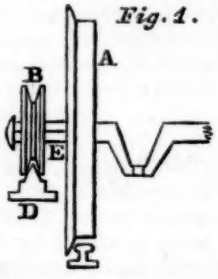
Specifications of American Patents.

Specification of a Patent for a method of enabling Locomotive Engines and their trains to ascend Inclined Planes, on Rail-roads; granted to William F. Ketchum, *Buffalo, Erie county, New York, March 20th,* 1839.

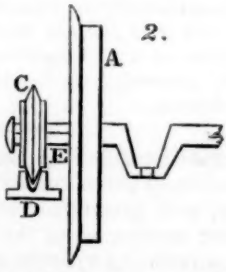
To all whom it may concern: Be it known, that I, William F. Ketchum, of the city of Buffalo, in the county of Erie, and state of New York, have invented an improvement in the mode of constructing the wheels of Locomotive engines, and of rails adapted to such wheels, by the aid of which, locomotives with the trains attached to them, may be made to ascend inclined planes, the adhesion of the wheels to the rails being increased, without the employment of cogs, whilst said wheels may be reduced in size to any desirable extent, thus increasing the power of ascent in the same ratio; and I do hereby declare that the following is a full and exact description thereof.

The ordinary driving wheels of the locomotive engine are made in the usual way, but on the same axis on which two ordinary wheels are fixed, I place another pair of wheels, on the outside of these ordinary wheels. The additional wheels may be made of such diameter as will adapt them to the grade of the inclined plane up which they are to ascend. The peripheries of these wheels are to be grooved, or channeled, in the manner of those pulleys, or wheels, which are to receive a rope, or chain; the form of the groove, or channel, may vary, but I most commonly sink it so as to form a V groove, but this is not a point of importance.

Fig. 1.



2.



3.

The wheels, constructed as above, are to run upon rails adapted to them, placed on a line with, and outside of the ordinary rails of the track, and raised above the ordinary rails to a height sufficient to raise the ordinary wheels above them, so that they may revolve freely without coming into contact with any thing. The rails adapted to the grooved wheels are to be ridge formed, so as to fit into the grooves of the wheels, and so that the sides

of the grooves may bind upon them in any desired degree. It will be readily perceived that the form of the groove and of the rail may be varied in any manner consistent with the main object of the construction, namely, that of causing the one forcibly to embrace the other. It will also be evident that the same principle may be varied by forming the groove in the rail, and the ridge upon the wheel; but this arrangement would be objectionable, as the grooved rail would retain any substance which might fall, or be placed within it. The extra wheels are to have some lateral play to adapt them to the unavoidable inequalities of the rails; and to admit of this I make the portion of the axis upon which they are placed, and the holes through the centres of the wheels, polygonal; or, if round, I check them from turning and allow them to play laterally, by means of a feather.

In the accompanying drawing A, A, figs. 1 and 2, represent the ordinary driving wheels, and B, C, the extra wheels, B, being grooved, and C, ridged, the rails, D, D, upon which they run, being made of a corresponding form. Fig. 3, shows that the rail D, though differing greatly from those in fig. 1 and 2, in its form, may still be forcibly embraced by the groove made in the wheel.

By placing the additional wheels on the outside of the ordinary driving wheels, I am enabled to vary their size from an equality with that of the driving wheels, to the smallest diameter at which they can be eligibly used on the steepest ascents. They can also be readily removed, and those of other sizes substituted for them, should it be desired, or they may be left off when it is desired to allow the driving wheels to run upon the ordinary rails.

I do not claim to be the inventor of the mode of increasing adhesion of wheels to the rails by making one of them with a ridge and the other with a groove, this having been previously done, the extra wheels for this purpose having been placed on the insides of the driving wheels; but what I do claim is an improvement in the manner of using such wheels, by placing them outside of the driving wheels, by which change they are much better adapted to the intended purpose than placed on the inside, as their diameters may be varied to any desirable extent; whilst, also, they may be readily removed, or others may be subsituted for them, as above specified.

William F. Ketchum.

Specifications of English Patents.

Specification of a patent granted to William Watson, *Junior, of the county of York, for an invention of certain improvements in the manufacture of liquid ammonia, by which the same may be made applicable to the purposes of dyeing, scouring, and other manufacturing processes.*—[Sealed 20th November, 1838.]

My improvements, in the manufacture of liquid ammonia, by which the same may be made applicable to the purposes of dyeing, scouring, and other manufacturing processes, consist in a more economical method of manufacturing it; but although I do not profess to make a pure solution of ammonia, I do make it pure enough for the purposes of dyeing, scouring, and other manufacturing processes: and again, although it is impure, it is entirely and distinctly a different thing from the impure solutions before used, and which are commonly called ammonia liquor, or gas liquor, or gas water;

and also from such partially purified solutions of ammonia as are made from these, for the purpose of making cudbear, or archill, which, however applicable to such purposes, have not hitherto been used in the processes of dyeing and scouring: but, in order to specify distinctly the process or method which I have invented for the manufacture of liquid ammonia, or what is commonly called ammonia, it may be needful to state that the impure solutions of ammonia are obtained from the distillation of bones and other animal matter; and also from coal, in the making of coal gas; but in this state it is connected with so many other substances, such as oil, tar, carbonic acid, &c., as to render it quite inapplicable to any useful purpose.

In order, therefore, to separate the ammonia from its impurities, it has hitherto generally been the practice to combine it with sulphuric or muriatic acid, which, by evaporation, produces the salts of sulphate, or muriate, of ammonia; and these salts are still further purified by exposure to heat, or by re-crystallization.

The impurities being thus removed, the ammoniacal salt is put into a retort or boiler, along with fresh slacked lime, and from this mixture is expelled a gaseous ammonia, which being passed into water is absorbed, and forms the liquid ammonia.

In the process, which I have invented, I manufacture the liquid ammonia from gas water, and I dispense entirely with the use of sulphuric or muriatic acid, and of course with the evaporation and crystallization. I make it in the following manner:—the gas liquor, or gas water, collected at coal gas works, I put into a retort, or any other suitable vessel, along with fresh slacked lime, the quantity of which is to be determined by the quality of the water, and, by the application of heat, a tolerably pure ammoniacal gas is disengaged, which, being passed into water, forms a solution of ammonia.

When this distillation has been carried so far, that a considerable portion of steam, or the vapour of water, proceeds from the retort along with the ammonia, the ammoniacal solution, already formed, is to be removed,—this I call the first portion; and what is collected afterwards by a continuation of the process, I call the second portion; and, being very impure, it is put back into the retort with the next charge of gas water.

The first portion must be again submitted to distillation, with or without a small quantity of lime, and the same precaution must be observed as before, that is, so long as the principal part of what proceeds from the retort or boiler is ammoniacal gas, it must be passed into water; and when this ceases to be the case, as by continuing the heat, the water as well as the ammonia will evaporate, which may be known by the pipes or worm that are connected with the retort, and through which the steam passes, becoming heated by the condensation of it,—the solution of ammonia, already formed, must be removed;—this may be called the first portion of the second distillation. The process may be continued then until all, or nearly all of the ammonia is distilled; this second portion is to be returned as before to the retort.

The first portion of this second distillation is a solution of ammonia, sufficiently pure for common purposes; but it may be still further purified by distilling it a third time in the same manner as before, preserving for use or sale that portion only which is made by the absorption of the ammoniacal gas (or what is principally ammoniacal gas) in water, and returning to the retort the latter portions of the process, which consist of ammonia and water that has been distilled from the retort, and brought along with them a considerable quantity of impurities.—[*Inrolled May*, 1839.]

Lond. Jour. of Arts & Sci.

Specification of a patent granted to THOMAS ROBERT SEWELL, *of the county of Nottingham, for his invention of certain improvements in manufacturing white lead.*—[Sealed 14th July, 1838.]

My invention of improvements in manufacturing white lead consists in the four following particulars:—first, a peculiar mode of manufacturing an oxide of lead, which will be found more suitable for conversion into white lead than those oxides known in commerce under the names of litharge and massicot; second, the production of a superior quality of white lead, into the composition of which a larger proportion of metallic lead, or a smaller proportion of carbonic acid enters, than into an equal weight of carbonate of lead produced by the ordinary modes of precipitation; third, the employment of carbonic acid obtained in a state which is better adapted to the manufacture of white lead than that evolved in the combustion of charcoal, or other carbonaceous matters in atmospheric air; and fourth, a superior mode of operating in order to abstract from the white lead the matters with which it may be in a state of mixture at the time of its production.

The mode in which I manufacture the oxide of lead, forming the first head of my invention, is this:—I take the partially oxidized lead, obtained in the ordinary mode of making red lead, at that point of the process which immediately precedes its introduction into the oven to be converted into red lead. This preparation I have found to consist of a portion of metallic lead, protoxide of lead, and some red lead. I place these materials in an oven similarly constructed to those usually employed in the manufacturing red lead; in which oven, or other convenient receptacle, I submit it to a moderately red heat for about three or four hours. During this time it must be frequently stirred with an iron rake, or other suitable apparatus, in order to expose all the parts equally to the action of the heat. This process of heating, owing to the high temperature, instead of converting the materials into red lead, decomposes all the particles of the red lead, oxidizes the metallic lead, and brings the whole to the state of protoxide of lead, which is the substance required. Whilst the protoxide is in this highly heated state, it is to be expeditiously removed from the oven into a vessel, and closed up from the action of the atmosphere until cold, when it has become fit for use.

I have now two modes of effecting the second head of my invention, either of which I can employ. One of these modes is, by precipitating the white lead from solutions of oxide of lead, by means of alkali or alkalies, in combination with proper portions of carbonic acid: the other is by precipitating white lead from solutions of oxide of lead, by means of carbonic acid, obtained in manner hereinafter to be described, under the third head of my invention.

In order to precipitate white lead by the first mentioned method, I take a quantity of protoxide of lead, dissolved either in dilute nitric or acetic acid, which solution may be either in the state of dinitrate, trisnitrate, diacetate, or trisacetate of lead: the two latter I prefer; which, being substances well known to chemists, need no further description. To any one of these I add potash, soda, or ammonia, (which I prefer to be in a state of solution) in quantity just sufficient to neutralize the acid of the solution of oxide, and which alkaline materials must be previously in combination with as much carbonic acid as will be sufficient to convert the oxide of lead into dicarbonate of lead; but not enough to convert that oxide into carbonate of lead.

To ensure a similar result when I employ the carbonic acid in the state described under the third head of my invention, I pass such carbonic acid

through a mixture of oxide of lead, in a solution of acetic acid, or acetate of lead, or through a solution of diacetate of lead, or of triascetate of lead, or through a mixture of any of these materials,—and agitate the mixture during the passage of the gas, but stop the supply of carbonic acid in a very few minutes after the liquid arrives at such a state as would produce an acid reaction upon blue litmus paper, when dipped into it.

Under the third head of my invention, the carbonic acid which I employ, may be obtained from either of the five different combinations of materials about to be described.—First, one part of charcoal, coke-dust, or any other similar carbonaceous matters, with about seven parts of sulphate of lime, well ground, and intimately mixed together:—second, one part of charcoal, or coke-dust, &c., with about ten parts of sulphate of barytes, well ground and mixed as above:—third, one part of charcoal, &c., with about eight parts of sulphate of strontia, well ground and mixed:—fourth, three parts of charcoal, &c., with about fifty parts of carbonate of lime, and one hundred and twenty parts of sulphuret of lead, well ground and mixed.

Either of the above combinations of materials are to be placed in a retort of the same construction as those used for distilling coal in the ordinary production of illuminating gas. The retort being heated to a bright red must be continued at that temperature as long as any gas can be generated, and the gas conducted into an hydraulic main, kept constantly supplied with water, and thence into a gas-holder, from which it may be pumped, or otherwise forced through a vessel of water, and brought into contact with the materials about to be converted into white lead.

The fifth mode of producing carbonic acid gas is, by placing charcoal, or coke, or other similar carbonaceous matters, broken into small pieces, in an earthen retort, and when heated to a bright red, passing a current of steam through the materials in the retort, which will cause the steam to be decomposed, and carbonic acid gas to be produced, with small portions of other gases not injurious to the subsequent operation of making white lead. These gases are to be collected in a gas-holder, and applied in the manner before described.

The improved mode of washing white lead, which forms the fourth head of my invention, is effected under pressure.

White lead is produced in various ways, but most frequently in a state of admixture with acids and other matters, which it is necessary to remove by washing in water previously to the white lead being dried and prepared for market. This operation of washing has to be repeated several times in large volumes of water, and when it is desired to recover the acids and other matters so washed away from the lead, the very great quantity of water which must be evaporated in concentrating the matters contained in the water renders the operation difficult and expensive. To obviate this inconvenience, I perform the washing of the lead under either pneumatic or hydrostatic pressure, by which means I am enabled to cleanse the lead effectually by a comparatively small quantity of water, and also to save much of the time usually required for the lead to subside.* Jour. Arts & Sci.

* The apparatus employed by the patentee is figured in Newton's Jour. for November, 1839.

***Specification of a patent granted to* WILLIAM WATSON, *Junior, of the county of York, for certain improvements in the manufacture of materials used in the dyeing of blue and other colours.*—[Sealed 8th November, 1838.]**

My improvements, in the manufacture of materials used in the dyeing of blue and other colours, consist in certain processes of preparing indigo, in order to render it more applicable to the purposes of dyeing wool, cotton, silk, and other similar materials, either in the raw or manufactured state; and also in adapting such materials to the general demand of commerce and manufactures upon a large scale.

In order that the improvements may be more readily understood, I deem it necessary to describe one ordinary manner of operating upon indigo, to improve its colour, and make it more available for the purposes of dyeing, which has hitherto been as follows:—the indigo is ordinarily dissolved in sulphuric acid, and by filtering the solution, which has been previously diluted with water, the grosser and impure parts of the indigo are separated from the finer; to this filtered solution is afterwards added some salt or alkali, which precipitates the blue colouring matter in combination with the sulphuric acid; the precipitate being collected upon a filter, is now of the consistency of paste, and known in commerce as "extract of indigo."

The excess of uncombined acid which this produce contains, is sometimes, for still further improvement of the colour, and also for the convenience of dyers, removed by various operations, the details of which it is not necessary here to pursue.

Now my improvement in this process,—and in order to ensure the complete neutralization of the acid, thus rendering the colour more beautiful and pure, and securing the absence of all free uncombined acid,—is as follows:—I employ the hydrate of alumina in the manufacture of "extract of indigo," and in the following simple manner:—when the indigo has been dissolved in sulphuric acid, passed through the process already described, and the uncombined acid removed, as much as possible, by the ordinary means, I add to it hydrate of alumina, or alum, and ammonia potash, or soda, or any other materials, which, by their mutual decomposition, produce the hydrate of alumina; and, after mixing these well together, I place the mixture upon a filter, and allow it to remain until the paste is of sufficient consistency for sale or use.

Another method I employ, in order to improve the colour and quality of indigo to be used for dyeing, is lime, or orpiment and lime, or by other agents, by which indigo may be dissolved in *water*, such as potash, soda, or ammonia, fin-woad, &c.; and when such solution is made, it is allowed to remain at rest until the insoluble part of the indigo, and materials employed, have subsided; I then draw off the clear liquor, and, by exposing it to the action of the atmosphere, the blue colouring matter of the indigo is precipitated, which precipitate is to be collected upon a filter, mixed with diluted sulphuric, or muriatic, or any other acid, washed with water, and lastly dried; by which refining process I produce a beautiful and very pure indigo.

And also for a still further improvement of the colour of indigo, and for the more convenient use of it, I take indigo, refined by the process just described, and dissolve it in concentrated sulphuric acid, and this solution of refined or purified indigo, in sulphuric acid, I call *liquid* extract of indigo.

Lastly, I desire it to be understood, that I do not intend to claim such common or known processes as have been above alluded to, but the adaptation of such process or processes, upon a large scale, for the purpose of com-

merce and manufactures, and applying the product to the purposes of dyeing; and also the manufacture and application of liquid extract of indigo to the purposes of dyeing wool, woollen cloths, silk, cotton, or other goods, or materials.—[*Inrolled May*, 1839.] Ibid.

Specification of a patent granted to Joseph Davies, *of the county of Surrey, for his invention of a composition for protecting wood from flame.*—[Sealed 13th August, 1838.]

My invention is a composition of the substances hereinafter mentioned, combined with glue or size, or other animal gelatinous matter in manner hereinafter stated. The substances used are slate, slate dust, stones, sand, clay, and earth; any of these substances may be used separately, or any or all of them may be used together. All articles made and consisting of any of these substances, such as earthenware or bricks, may be used, but I prefer slate or slate dust; and when I use clay or earth, I mix sand or slate dust with it, as I find a composition binds better when so mixed.

Before using any of the above substances which are not already in a state of powder, I reduce them to powder by grinding in a mill, or otherwise. I boil the substance or substances with the glue or size, or other animal gelatinous matter, in a boiler, pot, or pan, frequently stirring the composition until the whole becomes thoroughly amalgamated, and of a proper consistency for use. I find that the proportion of one-twentieth of the gelatinous matter to the quantity of the substance or substances used, produces the best and most effectual composition; but an inferior composition may be made with a less proportion of gelatinous matter.

I apply my composition to the wood with a trowel or other suitable instrument, in the same manner as common stucco or plaster, in such thickness as may be deemed necessary:—in ordinary cases, for ceilings and floorings, I make it from half an inch to an inch in thickness, and thinner in places less exposed to danger. The composition may be applied immediately in the state in which it is taken from the boiler, but if it is not required for immediate use, it should be suffered to cool and dry, and it should be again reduced to powder, by grinding or otherwise, before it is used; it is then to be mixed with water, as in making common mortar. Ibid.

Progress of Practical and Theoretical Mechanics and Chemistry.

On the theory of the Formation of White Lead. By Mr. Benson.

The carbonate of lead formed by the common process, is anhydrous, amorphous, and contains one proportional each of carbonic acid, oxygen, and lead. In order to explain my views (says the writer,) I shall have to advert, for a moment, to the oxide of lead, termed litharge. Litharge is seldom manufactured with a view to its ulterior application, as it is produced as a secondary product in the separation of silver from lead, even under Mr. Pattison's arrangement, in quantities too large for the demands of commerce. A considerable proportion of the lithage made must, therefore, necessarily be reduced again into the metallic state, and, during this reduction, seven per cent. of the weight of the metallic lead is lost by sublimation, and by combining with the earthy matter of the coal. Now, as litharge is a pro-

toxide of lead, it has been thought, that in order to effect its conversion into white lead, nothing more was requisite than to combine it with a due proportion of carbonic acid; and from this mistake, a variety of fallacious processes have been projected. The processes to which I allude, are founded upon bringing the litharge into solution as a basic salt, and then precipitating it as a carbonate by the injection of carbonic acid. Painters maintained, that this precipitate was not white lead. Chemists, finding, by analysis, the correct proportions of protoxide of lead and carbonic acid, attributed the opinion of painters to prejudice. Dr. Ure was, I believe, the first to discover in what the difference between the precipitated carbonate and white lead consisted. I have already sated, that white lead produced by the usual mode of manufacture is amorphous, and in oil, opaque; whilst, by microscopic observations, Dr. Ure has ascertained, that the former is semi-crystalline, and, to a certain degree, transparent. The difference between white lead and precipitated carbonate may be illustrated by comparing them to pulverized chalk and powdered marble; both are carbonates, but the one is crystalline, the other is not, and one is, consequently, less opaque than the other; and this difference is, of course, more appreciable, when the powders are diffused through highly refracting media, such as oil. There is one mode by which this difficulty may be avoided, and this was arrived at previously to the discovery of Dr. Ure, as a deduction from a different train of reasoning. The rationale of both the processes, of that which produces the crystalline, and of that which produces the amorphous carbonate, is the same. In both, the lead is converted into basic acetate—in both, the salt is decomposed by carbonic acid, but in the former the process is modified by the pressure of water. In the one, the carbonate has been deposited from a solution—in the other, the particles, never having departed from the solid state, have not been at liberty to arrange themselves symmetrically. In order, therefore, to produce amorphous carbonate, or white lead, from litharge, it became necessary to present the oxide of lead with a quantity of acetic acid so minute, that an insoluble basic salt should be formed, with a quantity of moisture merely sufficient to determine the action of the carbonic acid. The process would then resemble, in all respects, the ordinary one, except that in the one the lead has been previously converted into oxide, in the other, the formation of the oxide goes on simultaneously with that of the carbonate. The process has been carried out on a scale of considerable magnitude at Birmingham Heath. The quantity of acetic acid used is less than 1.300th of the weight of the litharge, and the quantity of moisture found to be most advantageous is such as will just render the litharge sensibly damp to the touch. A purer and more economical source of carbonic acid than bark has been found in the combustion of coke, and powerful machinery has been applied to facilitating the process, by exposing new surfaces to the action of the gass. The result has been, that the process is completed in as many days as the ordinary one requires months, and the product is of a purer white, and in opacity or body, and all other respects, at least equal to the usual white lead of commerce. One or two other facts deserve mention, which are not generally known. It is singular, that if the protoxide of lead known as massicot, and the protoxide known as litharge, be exposed to a high temperature, approaching to a red heat, the massicot will rapidly absorb oxygen, and become the ordinary red lead of commerce; while the same process goes on exceedingly slowly with the litharge, if at all; but, on the other hand, if massicot and litharge be moistened with dilute acetic acid, and exposed to carbonic acid, the litharge will

be converted into carbonate before the massicot is much affected. Another fact is, that white lead and oil combined with so much energy, that if linseed oil be poured upon a large quantity of white lead, and the mass be left undisturbed for a few hours, the temperature will become so elevated, as to carbonize the oil, and render the whole perfectly black. It seems also not generally known, that white lead possesses the power of destroying the colouring matter of linseed oil. If sulphate of barytes be mixed with one portion of oil, and white lead with another portion, the latter will appear comparatively white. If the two mixtures be allowed to remain for some days undisturbed, a quantity of oil will gradually rise to the surface of both. In the former, the supernatant oil will have undergone no change—in the latter, the oil will be nearly deprived of colour, and will have acquired the degree of rancidity, termed by painters, fat. The colouring matter has not combined, as might have been expected, with the white lead, for if this be dissolved by the agency of a weak acid, the disengaged oil will also be found to have been bleached. A large quantity of white lead is required to produce this effect, and the precipitated carbonate is less efficient than the white lead of commerce. Athenæum.

On the best means for Burning Gas for Supplying Heat. By Sir John Robison, *K. H., Sec. R. S. E., M. S. A.*

When carburetted hydrogen gas is employed in procuring heat, it is seldom required that it should at the same time give out light; the combustion may therefore be managed in any way which may be convenient, without seeking to preserve the illuminating power.

It appears to have occurred about the same period to the late Dr. Duncan and to myself, that, by passing a current of gas mixed with atmospheric air through a wide vertical tube having its upper end covered by a diaphragm of wire gause, and by kindling the mixture as it escaped through the interstices of the wire cloth, a convenient stove might be formed for culinary purposes. Dr. Duncan applied some small apparatus on this principle to pharmaceutical operations in his class room; and I had my kitchen furnished with a range of large stoves which were intended to supersede the use of French charcoal stoves in various culinary processes. In both cases the success has been perfect, and the same principle has since been adopted with advantage in a variety of processes in the useful arts, where this neat and cleanly method of applying heat has rendered it a valuable acquisition to the workshop. The form of the apparatus may be varied in any way to suit the particular process to which it is to be supplied; as all that is essential is, that a current of the mixed gas and air shall rise through wire cloth, and that the proportion of gas to atmospheric air shall never be so great as to allow of the flame becoming yellow, as with this precaution, the combustion of the carburetted hydrogen will be complete, and no deposit of soot will take place on cold bodies when set over the flames. The proper quantity of gas in the mixture is easily determined by the stop cock belonging to each stove.

For ordinary culinary purposes, the cylinders may be 30 inches long, and 3 to 4 inches diameter, and the wire cloth for the tops should have about thirty-wires to the inch. That which is manufactured for safety lamps answers well for this purpose.

Whenever, from accidental injury, or decay, a hole takes place in a

diaphragm, it is no longer possible to use it, as when lighted, the flame passes through the fracture and communicates with the jet at the bottom of the cylinder, which then burns like an ordinary gas light, and like it, would blacken the surface of any cold body presented to it. The wire cloths, if not broken through by violence, will last for months, although in daily use, and if covered by a layer of coarse sand, or pounded limestone will continue serviceable for an unlimited period.

When more intense heat is required than is attainable by the unaided combustion of the mixed gases, recourse may be had to various forms of blow pipes; and when a large volume of such flame is to be employed, the current of atmospheric air may be urged by double bellows. A very efficient apparatus on this principle is to be seen in the laboratory of Dr. D. B. Reid.

It is to be regretted that such applications of gas are not more generally known and introduced into workshops, as there are numerous processes in the arts in which they would afford facilities to the workman which he can scarcely command by any other means; for example, in the hardening of steel tools, it is well known that a piece of bright steel when heated to redness in a forge, or muffle, is subject to oxidation, and that a black scale remains after hardening, which it is difficult to remove without some injury to the work, as in the case of a screw tap; whereas, if the same piece of steel be heated in a flame of the mixed gasses, where there is no free oxygen to attack its surface, it may be *made and kept* red hot without any injury to its finest edge; it will be discoloured, but without losing much of its polish. The artist has also the advantage of a distinct view of the article while it is being heated, and the power of withdrawing it from the flame the moment it has acquired the proper colour, which in the hardening of cast-steel cutting tools is of great importance.

Many attempts have been made to apply carburetted hydrogen and pure hydrogen gases to the purpose of warming buildings, and a variety of forms of stoves have been proposed, on the understanding, it would appear, that. by applying the flame of the gas to metallic bodies, an increased degree of heat would be communicated by them to the atmosphere around them; a little consideration will show, that however the *distribution* of the heat may be modified by such contrivances, there can be no increase of the heating power; and that when a certain measure of gas is fairly burned, the heat evolved into the apartment will be the same whether the flame be disposed as a light or made to play against metallic plates, or other combinations of apparatus. In all cases where the products of the combustion are allowed to mix with the atmosphere of the apartment, without provision being made for carrying them off by ventilation, the effects of such processes must be more or less deleterious to health according to the proportion these products bear to the mass of air they mix in.

On the whole, it may be assumed that this mode of heating apartments is the most expensive, the least efficient, and, excepting that by Joyce's charcoal stove, the most insalubrious that can be resorted to.

Lond Mech. Mag.

On the Application of Electro magnetism as a Motive Power: in a letter from Prof. P. Forbes *of Aberdeen, to* Michael Faraday, *D. C. L., &c. &c.**

King's College, Aberdeen, Oct. 7, 1839.

My dear Sir,—Having seen a notice from Mr. Jacobi sent by you to the London and Edinburgh Philosophical Magazine,† regarding the success of

* Communicated by Dr. Faraday. † See L. & E. Philos. Mag. for Sept., p. 164.

his experiments on the production of a moving power by electro-magnetism, I am sure it will give you pleasure to know that a countryman of our own, Mr. Robert Davidson, of this place, has been eminently successful in his labours in the same field of discovery. For in the first place, he has an arrangement by which with only two electro-magnets and less than one square foot of zinc surface (the negative metal being copper) a lathe is driven with such velocity as to be capable of turning small articles. Secondly, he has another arrangement, by which, with the same small extent of galvanic power, a small carriage is driven on which two persons were carried along a very coarse wooden floor of a room. And he has a third arrangement, not yet completed, by which, from the imperfect experiments he has made, he expects to gain very considerably more force from the same extent of galvanic power than from either of the other two.

The first two of these arrangements were seen in operation by Dr. Fleming, Professor of Natural Philosophy in this University, and myself, some days ago; and there remains no doubt on our minds that Mr. Davidson's arrangements will, when finished, be found available as a highly useful, efficient, and exceedingly simple moving power. He has been busily employed for the last two years in his attempts to perfect his machines, during all which time I have been acquainted with his progress, and can bear testimony to the great ingenuity he has shown in overcoming the numberless difficulties he has had to encounter. So far as I know, he was the first who employed the electro-magnetic power in producing motion by simply suspending the magnetism without a change of the poles. This he accomplished about two years ago. About the same time he also constructed galvanic batteries on Professor Daniell's plan by substituting a particular sort of canvas instead of gut, which substitution answers perfectly, is very durable, and can be made of any form or size. And lastly, he has ascertained the kind of iron, and the mode of working it into the best state for producing the strongest magnets with certainty.

The first two machines, seen in operation by Dr. Fleming and myself, are exceedingly simple, without indeed the least complexity, and therefore easily manageable, and not liable to derangement. They also take up very little room. As yet the extent of power of which they are capable has not been at all ascertained, as the size of battery employed is so trifling and the magnets so few: but from what can be judged by what is already done, it seems to be probable that a very great power, in no degree even inferior to that of steam, but much more manageable, much less expensive, and occupying greatly less space, if the coals be taken into account, may be obtained.

In short, the inventions of Mr. Davidson seem to be so interesting to rail-road proprietors in particular, that it would be much for their interest to take up the subject, and be at the expense of making the experiments necessary to bring this power into operation on the great scale, which indeed would be very trifling to a company, while it is very serious for an individual by no means rich, and who has already expended so much of his time and money for the mere desire of perfecting machines which he expected would be so beneficial to his country and to mankind. For it deserves to be mentioned that he has made no secret of his operations, but has shown and explained all that he has done to every one who wished it. His motives have been quite disinterested, and I shall deem it a reproach to our country and countrymen if he be allowed to languish in obscurity, and not

have an opportunity afforded him of perfecting his inventions and bringing them into operation, when they promise to be productive of such incalculable advantages. L. & E. Philos. Mag.

New Variety of Carbon.

A specimen of the incrustation on the interior of a gas retort was produced; it was a coke of extreme density and of great value for some purposes, but for what was a secret. This deposition accumulates until the interior of the retort is almost filled up, leaving no available space for the charge. The retorts are bought for the sake of this coke, which is a perfect carbon. A thin coating of carbonaceous matter, which would otherwise be carried off in the gas, is deposited in each charge.

Mr. Lowe was not aware of the uses to which this coke could be applied; but it was of extreme disuse to the gas-makers; he believed, however, that it was used to produce an intense heat. It is sometimes stated to be a carburet of iron, but a portion from the centre of the mass shews, on being tested, not the least trace of iron. It arises naturally in the process of gas-making, and the rate of its deposition depends on the temperature; as in those retorts which have a tendency to become too hot the deposition goes on exceedingly fast. There were many curious facts connected with its deposition; that in a horizontal part is stratified in concentric layers. The upper portions will be perfectly sectile and form admirable crayons, that at the lower part will scratch glass; it decreases in density from the bottom; a portion of the sides partakes of both qualities. He suspected, that a large quantity was sold as black lead.

Mr. Williams remarked, that there were two kinds of peat, the one having a density due to impurities; this is useless for all purposes of metallurgy. —But for the purest carbon, the upper surface of the moss must be used, and an artificial density must be communicated to it; it is only in this manner that a dense and pure coke can be obtained. The peat having this artificial density is carbonized, by which all the volatile matter useless in combustion is driven off, ground, and then being mixed with a bituminous matter the operation of nature in the production of various species of coal may be closely imitated.—*Inst. Civ. Engineers.* Jour. Arts & Science,

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On the use of the Metal Palladium.

This peculiar metal, discovered by the late Dr. Wollaston, in the year 1803, was, for some years only known to exist in the native Platina, of Colombia. In 1812* it was noticed by Mr. P. N. Johnson, in the coin and small negotiable ingots of gold brought from the Brazils.

The rarity of the metal has hitherto prevented its general use, hence few of its valuable properties have been applied in the arts.

The development by the Imperial Brazilian Mining Association, of the gold region of the province of Minas Geraës, (which is peculiar for the existence of this metal in combination with the gold,) has of late years rendered its introduction more general in lieu of gold or platina, over which for many purposes it has its advantages, viz: it equally resists *sulphuretted hydrogen* and *mineral acids.*

It requires a much greater degree of heat for fusion than gold. Its specific

* See the Philosophical Magazine, vol. xl, page 4.

gravity is only about half that of platinum, and as 11½ is to 19 in relation to gold, and therefore it is more economical in use.

Its price is not one-eighth of that of gold, and less than half of that of platinum, calculating equal bulk.

It may, without injuring its properties, be brought to almost any extent of hardness or softness.

Its chief uses at present are confined to dental surgery, in graduated scales for astronomical, nautical, and other instruments, in springs for various purposes, for lightning points, inoculating lancets, and ornamental works of different descriptions.

It is separated from the gold by solution from nitric acid, and from some other metals by addition of caustic ammonia and hydrochloric acid; which process was discovered by Mr. P. N. Johnson, in 1817, and is preferable, both in economy and purity, to the use of prussiate of mercury. Ibid.

Description of a Machine for cutting the teeth of Bevel Wheels. By Mr. Davies.

In consequence of the importance of the subject, the attention of practical and scientific men has been for some time devoted to the inquiry, and, at the Liverpool meeting of the Association, Prof. Willis communicated the results of his investigations. The mechanical invention now explained, was to provide the means by which any form, when determined, could be accurately obtained, but applied more particularly to the formation of the teeth of bevelled wheels. In constructing this apparatus, Mr. Davies availed himself of the well-known planing machine, which provides the means of bringing any piece of work attached to its moving table, in contact with th ecutting tool of the machine, the cuttings thus produced being in lines parallel with the bed. The arrangement for the machine provides for the wheel being caused to have a revolving movement either in a horizontal or a vertical plane, the combination of these two movements being similar to that of a universal joint. A lever or guide-rod is attached to the frame at one end, and at the other it is confined by a slit, which it fits exactly. The slit is formed in a vertical piece of metal which is attached to the movable table of the machine. Motion is given to this guide by means of a screw, when it describes the exact curve of the slit, and this movement is communicated to the bevelled wheel through the frame to which it is attached. As the part of this guide-rod which, by its traversing, influences the form, is much more distant from the centre of motion than the wheel, any error in the form of the slit will be diminished on the wheel in direct proportion to these differences. The only precautions requisite in using this machine are to insure that the centre of the cone, which would be formed by the extension of the bevelled wheel, is true with the centre of the bearings; and that the cutter be so placed, that in the traversing of the machine, the centre point will constantly approach the cutting point of the tool.

Athenæum.

Anhydrous Protochloride of Tin.

M. Capitaine gives the following as a simple and very economical method of preparing anhydrous protochloride of tin:—Heat the muriate of tin of commerce in a large Hessian crucible; it is not possible to perform the operation in a retort, as some authors advise, for the salt swells and passes over into the receiver without undergoing any alteration; when moderately heated

in the crucible it fuses, swells and yields the vapour of water and of hydrochloric acid; soon after this it undergoes igneous fusion, and when in quiet fusion it is to be poured into a smaller crucible. On cooling it becomes a brown mass, which is to be reduced to coarse powder and distilled in a coated glass retort. The first product is perfectly pure, the latter contains a little iron, which is to be separated by redistillation. The properties of this substance are that it is compact, nearly of a pure white colour, brittle, and has a vitreous fracture; when heated it fuses at about 482 deg. Fahr., boils, and volatilizes at a little below a red heat. It possesses a property which must always prevent the density of its vapour from being ascertained, which is that it is never completely volatilized without undergoing partial decomposition, the results of which are perchloride of tin, and yellow, earthy subchloride of tin, which remains in the distilling apparatus. When in a state of fusion it has a great tendency to penetrate the crucibles.

It dissolves in water without undergoing any immediate change; but the liquor remains clear only for a short time, and soon becoming turbid, it deposites oxychloride of tin. After a considerable time, in contact with the air, the oxychloride dissolves, and the liquor becomes clear and transparent.

Absolute alcohol dissolves it very readily, and more when hot than cold; by cooling the solution becomes syrupy. After some time the solution acquires a distinct odour of hydrochloric æther. When exposed to the air it long retains its property of precipitating the chloride of gold purple, and it does not become turbid. The protochloride of tin when anhydrous, is much less alterable by exposure to the air than when it contains water; indeed, unless it be hydrated it does not appear to absorb oxygen; after three weeks' exposure it remains completely soluble in water. Mining Jour.

The Effects of Kyanising Wood.

The effects of kyanising wood, with reference to living plants, has been noticed in different parts of the present volume. The result seems to be, that the Kyanising liquor is made so strong, that more corrosive sublimate is deposited, not only on the outer surface of the wood, but in its interior pores, than is wanted for entering into combination with the albumen. This superfluous quantity, then, in the case of hot-house rafters or sash-bars, being sublimated by the great heat of the house, escapes even through several coats of paint, contaminates the atmosphere, and injures vegetation for a time, till the source is exhausted. As the wood, when steeped in the Kyanising fluid, absorbs water in a considerable quantity, as well as mercury, it is easy to conceive that the heat of a hot-house will raise the temperature of the rafters and sash-bars, which are always in the hottest parts of the house, to such a degree as to expand the water into vapour, as well as the corrosive sublimate; and, thus pent up, the elastic fluids produced will readily burst through any layers of paint that could be laid on. A safe mode, when Kyanising for plant structures, would appear to be, to use the Kyanising liquor much weaker than is generally done; and, after the wood is removed from the tank, to dry it as thoroughly as if it had not been Kyanised, in order to get rid of the water absorbed during that process. Gardener's Mag.

Peat and Charcoal.

Mr. Farey alluded to the charcoal, or peat coke, which Mr. Oldham em-

ploys at the Bank of England; this is in thin cakes, and denser than the heaviest wood. Mr. Bramah remarked on the great value of compressed peat, could it be procured at a marketable price, on account of its superiority as a fuel for making large weldings.

The preceding minutes having been read, Mr. Parkes stated that the greater part of the charcoal used in Paris is from peat. The peat charcoal is preferred to the very best wood charcoal. There are two modes of making this charcoal: In a Swedish furnace, which is an oven made of lumps of peat, the pieces to be carbonised are placed in the interior, ignited, and smothered up in the usual manner. The other mode consists in getting peat as dense as coal, by allowing the small atoms to come within the natural force of cohesion. The peat for this purpose is dredged up from the bottom of streams, and laid up to dry, and formed into small bricks, which, on drying, contract very much. Compression will not do. In Holland they dig the turf and put it into running water. The water cannot be driven out by pressure. He had seen peat compressed with a force equal to that for pressing bowls for calenderers, but it was not near so dense as that formed by the natural means just alluded to.

Mr. Pellatt remarked, that the coking of coal does not deprive it of the sulphur. Washing the coke will remove much that remains; but even then it cannot be used for welding glass—nothing but the purest beech wood will serve for this. Charcoal will not answer, as it requires a flame. By welding, he meant the operation of putting a handle on a vessel. The glass being of a proper temperature, a union is formed, provided no sulphur be present.

Mr. Lowe remarked, it had been practically found that beech charcoal is valuable because of the quantity of carbon it contains. There is more pure carbon in a given weight of beech wood than of any other kind. Oak is the next best.

Inst. Civ. Eng.

On a remarkable property of Electric Tension.

M. C. Doppler, Professor of Mathematics, at Prague, has said that he has discovered that a feeble electric charge given to a bar of insulated metal causes it to contract; and, of course, if negatively electrized, the metal expands. The following is the method employed in the experiment:—

A thin copper tube, about three feet long, is properly placed in a delicate compound lever-apparatus, something similar to our lever-pyrometers, and properly insulated by glass stems. If now, a feeble electric tension be given to the tube, the index of the lever-apparatus immediately begins to move, indicating a *contraction* of the tube. By increasing the *tension*, the motion of the index is so swift that the eye cannot trace it; so that for high electric tensions a simple lever-apparatus answers better than the delicate compound one. When sparks are either intentionally taken from the tube, or that they are discharged spontaneously, the index rapidly recoils, indicating an *expansion* (prolongation) of the tube; which *contracts* again by an increase of electric tension. This property of electricity is said to have been discovered by a single pair of plates; and, as Poggendorff has justly said, "probably by an electric current," which would render the circumstance still more curious, unless the current produced a depression of temperature in the tube.—*Poggendorff's Annalen.*

Sturgeon's Annals.

Electric Deflagrations.

Mr. Mason, of High Holborn, who is an exceedingly dexterous experimenter, has lately discovered a method of enhancing the beauty and splendour of charcoal deflagrations by voltaic electricity. He powders bichromate of potash and places the powder on the points of the charcoal, and when the latter has become red hot, the bichromate also enters into deflagration. The light produced is two-fold that given by the charcoal alone. The potash becomes decomposed and the liberated potassium scintilates in a very beautiful manner. We have seen Mr. Mason produce a beautiful effect with a battery of only thirty small jars.

Speaking of deflagrations, perhaps it may be interesting to some of our readers to know that the laminated metals, such as gold, silver, or copper leaf, &c., give a good effect when deflagrated on a strip of bright tin plate, which may be connected with one pole of the battery, whilst the metallic leaf, placed on a long copper wire in connexion with the other pole, is passed gently over its surface. Gold gives the feeblest light, copper next. The light from white Dutch metal is much more brilliant, and of a pale purple tinge. That from silver is exceedingly handsome, being a pale greenish yellow. We have, for many years, used zinc turnings for deflagrating at the lecture table. They burst into a complete blaze, and become converted into *philosophical wool*, which floats in the air for a long time afterwards. Ibid.

Case Hardening.

At the British Institution of Civil Engineers the conversion of iron into steel was discussed, and it was stated that iron could be converted into steel by immersion in pure carbon, as in the Macintosh process, at the rate of $\frac{1}{30}$th of an inch per hour. Mr. Roberts stated that the success of case hardening depended on the gentleness of the heat. Great care must be taken not to overheat, and case hardening might take place to the depth of $\frac{3}{8}$ths of an inch in four or five hours. It was stated to be cyanogen united with iron which produces case hardening, but carbon which produces steel. An instance was mentioned by Mr. Carpmael in which animal charcoal was used for case hardening the interior, and vegetable charcoal for softening the exterior. Allusion was made to the fact, that the most perfect chill is obtained by the employment of moulds red hot. Inst. Civ. Eng.

Progress of Physical Science.

On the Origin of the Vegetation of our Coal Fields and Wealdens. By* J. T. Barber Beaumont, Esq., F. G. S.

A visit which I made during the last summer to the fossil trees recently discovered, apparently standing, as they grew, and rooted in an upper seam of coal in the line of the Bolton and Manchester Railway, has confirmed me in an opinion which I have always entertained, that the adopted theory of our coal-fields and wealdens being ancient deposits of trees in rivers and estuaries, is erroneous. The visible appearances to the contrary are now so many, and the anomalies they form to the doctrine taught are so puzzling

* This paper was read at the meeting of the Geological Society, on the 20th day of November.

to young geologists, that I think it high time that this theory should be reconsidered. I think the facts prove, that in no instance is it likely that these formations arise from drifted trees sunk to the bottoms of mighty rivers and estuaries, but, on the contrary, that the coal vegetations grow where they are found, and that these places were the surfaces of small islands.

The adopted theory supposes that the coal-fields occupy the bed of "a mighty river or estuary," into which trees have been drifted and deposited; and that the alternating strata of coals and shale have resulted from successive deposits of plants, and of clay, sand, &c. Drifted trees in the deltas of some of the largest rivers are referred to as typical of these ancient masses of vegetation; and it is observed, that the coal formations and wealdens extending over Great Britain and the north of France do not much exceed the extent of the delta of the Mississippi or the Niger.

The first observation that strikes me on this theory seems fatal to its existence in toto. A mighty river or delta could only have existed in a mighty continent—a small continent would not do; there is no very mighty river or delta in Europe. Then the coal strata (near Newcastle) with the intermediate shale, are collectively 380 yards in thickness; the first deposit, therefore, must have been in a river or delta of that depth, which is about six times the mean depth of the German Ocean! What a continent there must have been to have produced a river or delta so wide and so deep! Such a continent we might reasonably expect would leave an abundance of fossils on its surface, as well as at the bottom of its great river; we ought to see fossilified timber trees, and bones of continental quadrupeds, for hundreds of leagues around; but, with a few exceptions of small extent, not a single timber tree, not a trace of a land animal is any where discovered. This absence of land fossils, I submit, is proof positive, geologically speaking, that there could have been no extensive continent within which the supposed river or delta was formed; but the proof goes further—all this land, for hundreds of leagues around the coal and the wealden vegetations, swarms with the remains of marine animals, in addition to marine plants, and nothing else—it is visibly ancient sea-bed.

But let us look at the composition of the actual coal-fields; not a large timber tree, or bone of a land quadruped is to be found in them; all that we see are masses of fern, rushes, canes, and the like, except in the upper strata, on which coniform trees are found, some of them in their growing position; but the principal beds extend for many miles, nearly of an uniform thickness, generally of only a few feet, and sometimes of only a few inches. It is truly stated, "The surface of these strata shows the bending branches, with their delicate apparatus of foliage, almost in the beauty and vigour of their primeval life." But if the strata were formed from drifted and sunken timber trees—and such, I submit, would not have failed to be supplied by an extensive continent—some massive trunks of trees would have occurred to disturb the uniformity of the thin coal seams. The superincumbent pressure did not flatten "the festoons of graceful foliage," or "bending branches," for they arise above the coal strata, and mingle with the shale over them. That pressure, therefore, could not have crushed the trunks and roots of timber trees to obliteration, had any existed, within the thickness of the coal seams; but the evenness of the coal strata is unbroken by any trunks and roots of timber trees. This, I think, completes the proofs that the coal seams could not have been composed of drifted trees, sunk in the depths of a mighty river. There is also natural evidence against the

vegetations being formed from sunken trees of any kind, in the vigour and freshness of their appearance; while in that state they would not have sunk at all, but have floated out to sea, as at the present day timber trees from America drift on our own coasts. To have sunk in the deep river they must have first rotted! But this could not have been, for the foliage is found with the "freshness and vigour of primeval life." Moreover, drifted trees are stopped in deltas from the shallowness of the water being insufficient to float them on; we know of no deposits of trees in deep water.

An eminent geologist, seemingly aware of the necessity of providing a continent for this great river or estuary, supposed that it might have been in the German Ocean; while another eminent professor, to whose labours the public are greatly indebted, finding that area too small, crosses to the other side, and speculates on the possibility of its having been in the Atlantic Ocean. But the speculations of there having been a mighty continent in an ocean far off to the east or to the west of our great river or estuary, is of no use whatever; to help the case, the continent must have actually encompassed the river or estuary; but all around the supposed river deposits, for hundreds of leagues, has been visibly sea-bed! There can be no river, mighty or minute, in a sea-bed. Further evidence and argument, in disproof of this theory, therefore, seems unnecessary.

In offering an opinion upon what really has been the origin of the coal-fields and wealdens, I shall be more diffident, and very brief. To my understanding, they appear to have been swampy islands. It is reasonable to believe, that on the first elevation of the rocks, while some stood high above the ocean, others would be nearly level with its surface, and that disjoined fragments and drifted clay, sand, and shells, would accumulate into islands; these would give rise to a profuse growth of marsh plants, which decaying and regenerating, others would accumulate, in the manner of peat-bogs, to various heights; and ferns, palms, calamites, and coniferous trees, in some positions, would acquire a gigantic growth. It seems not unreasonable also to conceive, that after the great bursting up of the crust of the earth, large cavernous hollows would be left, and that there would be many settlements in the broken crust before it finally subsided. An island, sunk beneath the ocean's surface by one of these settlements, would be covered with drifted clay, sand, and shells, and the tall cany trees upon it, if any, be broken down by the waves and detritus; new accumulations would again raise its surface above the ocean, somewhat like our coral islands; a fresh growth of plants would then take place, and then another settlement, and so on to the number of coal seams and shale that compose a formation. The coal seams and shale in some places, as near Newcastle, are unusually repeated, but repeated settlements of the surface would be no more than consistent with the extraordinary uplift they succeeded—in some cases also, depressions of the surface may have been followed by partial uplifts. Of such sighings of the earth we have examples even in our own time: the temple of Serapis is not one of the most modern.

The wealdens are still more easily recognised as ancient islands, raised after the coal-making heat and influence had gone by; we have only to suppose the coal and wealden herbaria to be as they most frequently present themselves to our eyes, the growth of the lands where we find them, instead of imagining them to be drifted deposits from an inconceivable continent to the bottom of a mighty but impossible river, and all the appearances about them will cease to perplex. Mining Jour.

On an anomalous Electric Condition of Iron. *By* MARTYN I. ROBERTS, *Esq.*

It is now some months since, that while prosecuting a series of novel galvanic experiments, I discovered a singular anomaly in the electric condition of iron, which is, that although iron if associated with copper as a galvanic pair is highly positive to the copper, yet when associated with zinc, it is more highly negative to the zinc than copper would be under similar circumstances; or in other words, that although copper and iron form a galvanic combination, in which the iron is in the same relation to the copper that a zinc plate would be, yet that iron and zinc form a galvanic pair that has a greater power of generating electric action than a similar sized pair of copper and zinc. This singular phænomenon will, I believe, lead the way to some important discoveries; but not to occupy too much space in your valuable Journal, I will without further comment give extracts from my note-book of some experiments made by me on this subject.

Jan. 1st, 1839. A galvanic combination of iron and zinc was put in communication with two poles of a differential galvanometer; a like-sized combination (or gal. pair) of copper and zinc was connected with the other two poles of the diff. galvanometer: Deviation of needle in favour of the iron and zinc pair = 25 degrees.

Feb. 27, 1839. Experiments made on the comparative power of two galvanic batteries fitted up on Wollaston's plan (that is with the negative plate opposed to both surfaces of the zinc or positive plate.) The size of the plates was the same in both batteries, viz. zinc plate $2\frac{1}{8}$ inch. by $2\frac{1}{4}$ inch. The number of pairs in each battery was ten. The only difference between the two batteries was, that the negative plates in one were of copper and in the other of iron.

The exciting solution was dilute sulphuric acid, which was not renewed during the experiment, but the experiment was continued until the acid was exhausted. The power of each battery was applied to the decomposition of water, and the gas collected was the measure of the power.

RESULTS.

Battery of Copper and Zinc.

The first cubic inch of gas obtained		in 33 minutes.
Then one half cubic inch	"	in 92 minutes.
Acid was now exhausted. $1\frac{1}{2}$ cubic inch		in 125 minutes.

Battery of Iron and Zinc.

First cubic inch obtained		in	7 minutes.
Second	" "	in	9 minutes.
Third	" "	in	26 minutes.
Fourth	" "	in	62 minutes.
Acid now exhausted. 4 cubic inch.		in	104 minutes.

Iron battery with a measured quantity of acid gave 4 cubic inches in 104 minutes.

Copper battery with a like quantity of acid gave only $1\frac{1}{2}$ cubic inch in 125 minutes.

L. & E. Philos. Mag.

Microscopic Geology.

Professor Ehrenberg, already so justly famed for his microscopic discoveries in the animal and vegetable kingdoms, has recently added fresh lustre to his name by the pursuit of geological science. He has discovered that large masses of rock, and even whole strata of the earth are entirely composed of the remains of microscopic animals. The soft internal parts of these animalcules were, during life, covered with a tegument or case, composed of silica or flint; these earthly integuments have hitherto resisted decomposition, and now, in countless myriads, compose large portions of the globe. The cases are for the most part cylindrical, with transverse markings, and so hard, that the rocks composed of them are used as polishing stone. Of about eighty species of fossil infusoria which have been discovered in various strata, about one-half are identical with those which still exist in the waters; so that these classes of invisible creatures have a durability which has been denied to larger forms of life. Professor Ehrenberg has discovered that these microscopic animals exists at present in such abundance, under favourable circumstances, that there is no difficulty in accounting for the presence of the immense masses of their fossil remains. In the public garden at Berlin, workmen were employed for several days in removing wheelbarrows full of materials which consisted entirely of them. Ehrenberg has also succeeded in producing from masses of the living animals, tripoli and polishing slate, similar to the rocks from which he had originally obtained the remains; and he has added another to the numerous proofs of the correctness of the modern theories of geology, by showing that, while the microscopic contents of the more recent strata are all fresh-water infusoria, those of the chalk are animals which must, or at least could, have lived in the ocean. These discoveries were the result of great labour. Professor Ehrenberg had made a study of recent infusorial animalcules, during many years; and when his attention was drawn to the subject of fossil infusoria by M. Fisher, in 1836, he was able to recognise at once many species, which, in a living state, had been long familiar to him. Specimens of the rocks to which we have above alluded, and of the infusoria which compose them, are at present to be found in most of the mineralogical collections of Great Britain.—*The European.* Mining Jour.

New Theory of the Tides. By Prof. Whewell. *Cambridge Philosophical Society.*

At a meeting of this Society on the evening of Monday the 11th of November (Dr. Hodgson, the President, being in the chair), Mr. Whewell explained a new theory of the tides. The phænomena of the tides have hitherto been referred to the *equilibrium theory*, the elevation of the waters which occasions the tide being compared with the elevation which the moon would produce in the ocean if the earth and moon were both at rest. But the general motion of the waters of the ocean does not countenance this theory, or allow us to suppose that a fluid elevation resembling that of the equilibrium spheroid *follows* the moon from east to west; for the Pacific, the largest ocean, has no tide in its central parts; and at its eastern shore, near Cape Horn, the tide wave runs from west to east, although there is nothing to prevent its following its natural course.

The new theory which was offered was this:—The tide of each large

ocean may be considered as nearly independent of the tides of other waters. The central area of each ocean is occupied by a *lunar* wave, which oscillates, keeping time with the moon's returns, and having its motion kept up by the moon's attraction acting at each return. From the skirts of this oscillating central area, tides are carried on all sides by *free* waves, the velocity of which depends upon the depth and local circumstances of the sea; and thus the *litoral* tides may travel in any direction, while the *oceanic* tides near the centre of the oscillating area may be small or may vanish altogether.

This theory was confirmed by a reference to tide observations on the eastern and western sides of the Pacific, and by mathematical calculations tending to show that such a motion is mechanically possible. It was remarked that single observations can be of small use in deciding upon such a theory; and that it can be judged of only when we have observations numerous enough to enable us to draw the *systems* of cotidal lines which belong to the shores of the Pacific. With this view it is very desirable to obtain numerous and connected observations of the tides on the eastern shores of Australia, the Indian Archipelago, the Philippine Isles, the Loo Choo Isles, and Japan.

This theory to a certain extent coincides with the views respecting the tides published by Capt. Fitz Roy in his appendix to the voyages of the Adventure and Beagle. L. & E. Philos. Mag.

The Bude Light.

From the minutes of an examination of Goldworthy Gurney, and Dr. Faraday, before a committee of Parliament, on the Bude light which has been adopted as the mode of illumination in the House of Commons, it appears that this light is called the Bude light in reference to the residence of the former gentleman in Cornwall, where the experiments were made. His name was associated with the same light which we published an account of in 1823, and this was called the Bude light at the Trinity House by way of distinction.

The light is produced by throwing a stream of oxygen gas into the flame of a lamp, shaped like a small Argand. The interior of every flame being hollow, the vapour of the oil and the carburetted hydrogen is constantly liable to escape unburnt. The oxygen strikes the vacant carbon and vapour of oil as it is distilled, and produces an intense light.

Dr. Faraday testified that Gurney's lamp burns with remarkable steadiness for eight hours together, not requiring so much attention as an ordinary Argand lamp for the same time. There is no fear of danger from explosion, and the light can be managed by any person of common dexterity. The burners in the Bude light are rather more than a quarter of an inch in diameter and sixty burners consume about three pints of oil per hour. The lamps are so arranged that they can be raised and lowered to the amount of several feet, and the oxygen being brought to the light in small flexible tubes, the light may be moved about at the time it is burning.

Taking the price of manganese at 8 to 9 £ per ton, and estimating the usual wear and tear of apparatus and expense of fuel and attendance, the oxygen costs about 2*d* a cubic foot. There is an inexhaustible supply of manganese in Devonshire and Cornwall.

The lamp burned by Dr. Faraday gave a light of 20 Argands of $\frac{7}{8}$ inch

in diameter, and in twelve hours burnt six and four-tenths pints of oil, and used sixty-four cubic feet of oxygen. This he considers as the best proportion, though there is such power over the lamp that it can be increased to almost any intensity.

Abstracted from a statement of the examination in the Nautical Magazine for November, 1839. G.

Progress of Civil Engineering.

New Overshot Water Wheel.

The great overshot wheel, erected by the Kilgetty Colliery Company, at Merrixton, near King's Moor, Pembrokeshire, was set to work on Saturday the 7th ult., in the presence of a large assembly of the ladies and gentlemen in the neighbourhood. This wheel, we believe, is the most powerful in the principality, being of 75 horse power; the diameter is forty-feet, and it is seven feet wide on the breast, and the buckets hold water more than one-third of the circumference. It is fixed in a manner that is quite novel in this country, the wheel being so closely shut in by finely-executed masonry, that the escape of water, without going to the buckets, is impossible. It works by eccentrics, giving a horizontal motion to the cranks, being the first application of this mechanical arrrangement to such a purpose. It is adapted to work two pumps, giving twelve strokes a minute to each pump. The water is diverted from the stream about two miles from the wheel, and it is brought to it across the valley by an aqueduct, extending 300 feet in length, and from thirty to forty feet high. The wheel will supersede the use of steam power in the colliery, and it is contrived that, in time of drought, the water to be raised by the wheel will assist to drive it. The whole arrangements of the wheel are new applications of mechanism, and great improvements on plans hitherto in use. Considerable attention has been given to these works by parties who are not interested in them; and in the immediate neighbourhood, where so much enterprise at the present moment is in active operation in mineral undertakings, they well deserve the attention of all parties engaged in such enterprises. The works are close to the new road leading to Hobbs' Point, and may be conveniently inspected by parties travelling that way. The wheel and machinery were designed and executed by Mr. Thomas Dyson, of Downham, in Norfolk, where the wheel was made, and he has personally superintended the execution of the whole work. Although the wheel was made in order to drain the mine by pumps, it is understood the parties have since been advised to try instead the patent hydraulic belt, and intend to adopt it. A model was exhibited, and excited much surprise at its simplicity and its effective power to raise water on a small scale. Lond. Mech, Mag.

Statistics of the Iron Trade. By Hyde Clarke, *Esq., C. E.*

In 1826 this country was visited by a French statistician, M. de Villeghem, for the purpose of investigating the state of the iron manufacture, and he has given an estimate of the number of furnaces in that year, which seems generally accurate. The following is a table of the progress of each district, as far as it can be made out from the several authorities, although they are mixed up very confusedly. The returns of 1802, 1820, and 1827,

are from the Parliamentary returns; 1826, from the French estimate, and 1839 from the one given in the previous article.

	1802. Frn.	1820. Tons.	1826. Frn.	1827. Frn.	1827. Tons.	1839. Frn.	1839. Tons.
Scotland	28	20,000	56	18	36,500	50	200,000
Cumberland, Northumberland, Lancaster, & Leicester			84	24	43,000	32	86,000
Yorkshire	28	50,000					
Derbyshire	17			14	20,500	19	40,000
North Wales	—‡	—		12	24,000	16	48,000
Shropsite	42	180,000		31	78,000	40	150,000
Stafford	42						
Swansea District	—		78	95	216,000	125	400,000
Glocester	18		—	—	—	10	25,000
Monmouth			—	—	—	5	15,000
Merthyr District	52	150,000	78	90	272,000	120	550,000
	227*	400,000	305†	284	690,000	417	1,512,000

The following is M. Virlet's estimate of the amount of iron annually produced in Europe in 1835, with an annexed column of corrections to the present time:—

	M. Virlet. Metrical quintals.	Estimate. Tons.
England (1827)	7,968,000	1,512,000
France (1834)	2,200,000	600,000
Russia (1834)	1,150,000	150,000
Sweden and Norway (1825)	1,000,000	120,000
Austria (1829)	850,000	100,000
Prussia	800,000	100,000
Hartz Mountains	600,000	70,000
Belgium	600,000	80,000
Elba and Italy	280,000	28,000
Sardinia	225,000	22,000
Piedmont	[200,000]	—
Spain	180,000	18,000
Norway	[150,000]	—
Denmark	135,000	13,000
Bavaria	130,000	15,000
Saxony	80,000	10,000
Hanover	[10,000]	—
Poland	75,000	8,000
Switzerland	30,000	4,000
Total	13,433,000	2,850,000
Or about	672,000 tons.	

England produces about one-half the whole quantity, France about a fifth, Russia, Sweden, Austria, and Prussia, each about a twentieth. The total produce must be about three million tons.

* Total in blast. † 280 in blast, produce 728,000 tons. ‡ With Merthyr.

The following, illustrative of the importance of the English iron trade, is a comparison of some of the European, English, and French iron districts. It may be premised, by the bye, that South Wales alone produces about as much as all France put together, and Staffordshire, Scotland, and Shropshire, each surpasses any other European country:—

England.	Tons.	France.	Tons.	Europe.	Tons.
South Wales	550,000	Champagne	124,000	France	600,000
Staffordshire	400,000	Jura	83,000	Russia	150,000
Scotland	200,000	Ardennes	77,000	Sweden	120,000
Shropshire	150,000	Nievre	64,000	Austria	100,000
York, &c.	86,000	North West	35,000	Prussia	100,000
Total	1,386,000		383,000		1,070,000

In concluding this subject it may be noted, that, for the service of the South Wales district alone, 300 miles of railway are constructed.

Mining Review.

Difference of Longitude between Greenwich and New York.

I have the satisfaction to inform you of a second instance of the successful transport of chronometers from London to New York, for the purpose of determining the longitude of these two cities. The first, as you will remember, took place in the months of July and August last. The result then obtained was compared with that given by M. Daussy, a distinguished French hydrographer, in the *Connaissance du Tems*. The difference of these results was 2.63 sec. This was satisfactory under the circumstances of a first attempt, made in the first trip across the Atlantic of the *British Queen;* still I felt the difference to be too great to be permitted to remain without an attempt to diminish it, or to ascertain which of the two was nearer the truth. On the very next voyage, therefore, of the same vessel, and under the same friendly auspices of Captain Roberts, and my friends in the United States, I sent a second set of four chronometers from London to New York. Their rates, &c., were ascertained precisely as those of the first set, and the whole experiment conducted in the same manner. This voyage of the *British Queen* was made, out and home, in the last and present months. The result, I have the pleasure to announce, is this time, almost exactly the same as that of M. Daussy's; so near, indeed, that I feel it to be a duty, and one of the most pleasing nature, to express thus publicly my great admiration of the accuracy of his statement:—

	h.	*m.*	*sec.*	
By this second experiment the difference of longitude between the Observatory at Greenwich, and the City Hall, New York, is	4	56	0.24	W.
According to M. Daussy it is	4	56	0.72	
Difference of the two observations	0	0	0.48	

The difference of the two observations does not therefore amount to half a second! For all the purposes of practical navigation it may be regarded as nothing.

This very minute variation in the estimates of the astronomical distance

of two meridians so widely separated as those of London and New York, will be very gratifying to every lover of practical science both in France and England, the more so, when it is considered that these estimates were made independently of each other, "by different observers, in different years, and in vessels propelled by different agents." Perhaps it ought not to be omitted, that in both the English experiments the instruments were sent out unattended by any *savant*, and brought home their own report.

During the first voyage there had been observed in all the chronometers, a difference between the mean travelling rate and the mean stationary rate, which had the remarkable character of being always on the same side, viz., the *losing* rates were always *increased*, and the *gaining* rates always *diminished*. The same curious fact again occurred in the second voyage. From this circumstance the longitude of New York was given by each chronometer scarcely enough to the westward in the outer-bound voyages, and rather too much so in the homeward ones.

The great rapidity and accuracy with which this important branch of nautical inquiry may be pursued over the whole surface of the globe, as the agency of steam shall be extended, is now, I think, demonstrated. The instances under consideration show that observations may be made connecting very distant countries, and their several results compared in a few weeks —a circumstance of great consequence—for with the diminution of duration in a voyage, proceeds, in a higher degree, the diminution of all the chances and causes of error in chronometrical experiments at sea. Within the space of ninety-nine days, we have seen the *British Queen* carry chronometers *four* times across the Atlantic, and give ample time during each other of her visits to New York for the necessary observations of rates, &c.

All objections founded on the idea that the motion of a steam-vessel would affect injuriously the more delicate movement of the chronometer, and taint the results, must now fall to the ground. In the two voyages out and home of the *British Queen*, no derangement occurred, and the determination of the longitude of the far-distant ports she sailed between, is, probably, settled for ever, within the fraction of a second of the truth.

I am, &c.,

Ed. J. Dent.

Athenæum.

Instrument for Ascertaining the Temperature of Water at Great Depths.

In the extract which we published (p. 188) from Dr. Paterson's account of experiments on the temperature of Artesian Wells, an instrument is referred to as used by him in the course of his inquiry. At the request of several correspondents we take a further extract from the Doctor's interesting paper in the *Edinburgh New Philosophical Journal*, describing this instrument:—

"That objections might not be brought against this species of information, we used an instrument which has been long known for ascertaining the temperature of water at great depths. It consists of a glass-tube with brass ends which screw on; in each of these ends there is placed a valve, and both of the valves open upwards. It contains a thermometer, and is surrounded with a non-conductor; a string being attached to it, it is lowered down into the bored well. The water rushing up the bore, together with the instrument descending against it, causes both valves of the instrument to open, by which a free communication through the instrument by the valves is kept up, until it reaches the bottom of the perforation. The instrument is to be

allowed to remain there for a short time, and then withdrawn as quickly as possible. As soon as we begin to withdraw this instrument, the valves close, and consequently include a quantity of water from the lowest level, at which it has been.

"We have used the above described instrument on many different occasions, and in many different Artesian Wells, both those of recent and of several years' formation, and on no occasion did we find the slightest difference of temperature between the water taken at the mouth of the bore and that brought up by the instrument." Ibid.

Railway Reports.

The report presented to the proprietors of the London and Birmingham Railway, at the late half-yearly meeting, contains several statements of a highly satisfactory nature, to which we may here briefly advert, as all other companies must look with interest to the results afforded by this magnificent and ably-conducted undertaking. The directors remark that the receipts for passengers have been advancing steadily since the early part of the year; and it appears that the total number conveyed by the railway, for the six months, has been 267,527—the daily average for the whole length of the line having been 857. The revenue for the half-year amounted to 270,814*l.*; the charges upon this sum, including interest on loans, and a reservation of 14,000*l.* for depreciation of stock, was 165,684*l.*, leaving an available balance of clear profit (including a surplus of 7083*l.* from the previous half-year), amounting to 112,213*l.* It was recommended by the directors that a dividend of 3*l.* 10s. per 100*l.* share (7 per cent. per annum), and amounting to 109,375*l.*, should be declared; and the report was, of course, carried unanimously, having evidently produced feelings of satisfaction in every proprietor present. Mining Jour.

Improvement in Railway Carriages.

On Wednesday, a lecture was delivered at the theatre of the Mechanics' Institution, on a new description of railway carriages, invented by Mr. Coles of Charing-cross, and for which he has obtained a patent. The value of the invention was noticed in the *Mining Journal* at the time it was first made public, and by the working models exhibited, every statement formerly made was fully borne out. The improvement is, in the first place, by the addition of anti-friction wheels, which lessens the propelling power to one-eighth of that used by common carriages. Manual labour may be substituted for steam, and an increased speed is obtained; besides these advantages, the axles are formed on a safety principle, so that no irregularity of the railroad, or sudden curve, will cause the vehicle to run off, the axles working perpendicularly, horizontally, or obliquely, according to the position in which the vehicle may be accidentally thrown. Several eminent engineers were present, and gave their full approbation to the invention, and there is no doubt that in a short time the improved carriages will be used on the railroads. Ibid.

NOTICE.

A Meteorological Journal for the year 1839, has been received from an anonymous correspondent at Pittsburg. It appears to have been kept with care, and the Committee on Publications will be happy to insert it in the general report, if they are furnished with the name of the observer.

LUNAR OCCULTATIONS FOR PHILADELPHIA, MAY, 1840.					Angles reckoned to the right or westward round the circle, asseen in an inverting telescope. ☞ For direct vision add 180° ☜	
Day.	H'r.	Min.	Star's name.	Mag.	From Moon's North point.	From Moon's Vertex.
6	9	2	Im. μ' Cancri	6	44°	100°
6	9	58	Em.		266	322
8	10	59	Im. γ Leonis	5, 6	79	130
8	11	56	Em.		218	270
9	11	19	Im. δ' Sextantis	6	29	77
9	12	17	Em.		263	313
13	10	12	Im. 83 Virginis	6	357	358
13	10	59	Em.		289	302
18	15	27	Im. (359) Sagittarii	5	170	186
18	15	56	Em.		208	229

Meteorological Observations for November, 1839.

Moon.	Days	Therm. Sun rise.	Therm. 2 P.M.	Barometer. Sun rise.	Barometer. 2 P.M.	Wind. Direction.	Wind. Force.	Water fallen in rain.	State of the weather, and Remarks.
				Inch's	Inch's			Inches.	
	1	42	42	29.85	29.80	E.	Blustering	.34	Cloudy—rain.
	2	35	44	.95	.96	E.	do.		Clear—cloudy.
	3	38	41	.83	.75	E.	do.	.10	Partially cloudy—rain.
	4	38	52	.70	.70	N.E.	Moderate.		Partially cloudy—do.
⊗	5	41	58	.85	.85	N.W.	do.		Clear—do.
	6	40	55	.90	.93	N.W.	do.		Clear—do.
	7	42	45	.90	.85	E.	do.		Cloudy—drizzle.
	8	44	47	.75	.65	S.E.	do.		Rain—cloudy.
	9	44	41	.50	.35	N.E.	do.	1 25	Cloudy—rain.
	10	30	43	.55	.55	W.	do.	.30	Clear—flying clouds.
	11	28	41	.70	.70	E.SE.	do.		Clear—rains.
	12	32	40	.46	.48	NW.	do.		Clear—do.
☾	13	32	38	.90	30.00	W.	do.		Clear—do.
	14	30	41	.90	29.90	SW.S.	Calm.		Cloudy—do.
	15	33	35	.55	.45	W.	Moderate.	.38	Snow—drizzle.
	16	27	33	.50	.50	N.W.	Blustering		Cloudy—do.
	17	28	30	.80	.90	W.	Brisk.		Cloudy—clear.
	18	24	27	.90	.86	W.	Moderate.		Cloudy—do.
☹	19	20	28	.90	.95	W.	do.		Clear—do.
	20	23	29	30.05	30.05	W.	Calm.		Partially cloudy—clear.
	21	21	29	.03	.03	W.N.W.	do.		Clear—cloudy.
	22	30	32	29.70	29.40	E.	Blustering		Cloudy—snow.
	23	31	32	.50	.55	N.	Moderate.	.84	Snow—do.
	24	27	33	.75	.80	W.	do.		Cloudy—clear.
	25	26	35	.90	.90	W.	Calm.		Clear—lightly cloudy.
	26	22	39	30.00	30.00	W.	Moderate.		Partially cloudy—clear.
☽	27	29	34	.15	29.70	N.E.	Brisk.	1.75	Cloudy—snow and rain.
	28	36	33	28.80	28.80	SW.W	do.		Cloudy—snow.
	29	28	31	29.15	29.20	W	Blustering		Partially cloudy—do. do.
	30	22	28	.60	.71	W.	do.		Partially cloudy—do. do.
	31	16	23	30.05	30.05	W.	Moderate.		Partially cloudy—cloudy.
	Mean	30.93	37 39	29.74	29.72			4.96	

	Thermometer.		Barometer.	
Maximum height during the month.	58.00	on 5th.	30.15 on the 27th.	
Minimum " "	16.00	31st.	28.80 "	28th.
Mean	34.16.		29.73	

METEOROLOGICAL REPORT

FOR THE STATE OF PENNSYLVANIA,

Collated from returns made to the Committee on Meteorology of the Franklin Institute of the State of Pennsylvania, for

MARCH, 1840.

	County.	Town.	Observer.	Thermometer. 7, A. M.	2, P. M.	9, P. M.	Maximum.	Minimum.	Mean.	Days omitted.	Register. Lowest.	Mean.	Days omitted.	Bar. 7, A. M.	2, P. M.	9, P. M.
1	Philadelphia,															
2	Montgomery,															
3	Bucks,	Newtown,	L. H. Parsons,	37.90	50.11	39.68	70.25	19.00	42.56	.	16.00	32.68	.	29.86	29.81	29.85
4	Lehigh,															
5	Northampton,	Easton,	Lafayette College,	34.55	45.29	38.81	68.00	15.00	39.55	.	....	....	.	....	....	....
6	Monroe,	Stroudsburg,	A. M. Stokes,	35.93	48.76	38.23	75.00	16.00	40.97	$8\frac{1}{3}$	....	....	.	29.36	29.34	29.33
7	Pike,															
8	Wayne,															
9	Susquehanna,	Silver Lake,	E. W. Rose,	28.06	39.97	33.19	64.00	8.00	33.74	.	6.00	26.77	.	27.75	27.77	27.77
10	Luzerne,	Wilkesbarre,	W. F. Dennis,													
11	Schuylkill,															
12	Berks,	Reading,	C. F. Egelmann,													
13	Chester,															
14	Delaware,	Haverford,	Haverford School,	39.63	52.32	42.35	72.00	18.00	44.10	5	18.00	36.58	.	29.40	29.35	29.37
15	Lancaster,	Lancaster,	Conservatory of Arts,	39.33	54.61	43.07	75.00	20.50	45.67	4	19.00	36.26	2	29.31	29.27	29.34
16	York,															
17	Lebanon,															
18	Dauphin,															
19	Northumberland,	Northumberland,	Andrew C. Huston,	39.53	48.45	40.63	69.00	20.50	42.87	.	17.00	33.00	.	29.27	29.23	29.31
20	Columbia,															
21	Bradford,															
22	Tioga,															
23	Lycoming,															
24	Union,															
25	Mifflin,															
26	Juniata,	Mifflintown,	J. A. Rinkead,	36.63	50.88	42.82	75.00	11.00	42.82	2	....	....	.	29.34	29.30	29.32
27	Perry,															
28	Cumberland,	Carlisle,	Prof. W. H. Allen,	37.13	49.55	40.71	68.00	16.00	42.46	.	14.00	34.10	.	29.18	29.19	29.18
29	Adams,	Gettysburg,	Prof. M. Jacobs,	38.14	51.82	42.61	71.50	18.00	44.19	.	17.00	36.00	.	29.26	29.22	29.26
30	Franklin,															
31	Huntingdon,	Huntingdon,	Jacob Miller,	38.06	54.21	41.10	76.00	20.00	44.46	.	15.00	41.10	15	29.16	29.13	29.17
32	Centre,	Bellefonte,	John Harris,	33.45	42.93	37.70	70.00	13.00	40.03	2	10.00	30.10	2	29.08	29.04	29.13
33	Potter,															
34	M'Kean,	Smithport,	Richard Chadwick,	31.10	43.45	32.27	64.00	10.00	35.60	$\frac{1}{3}$	7.00	26.61	.	28.02	27.90	27.96
35	Clearfield,															
36	Cambria,	Ebensburgh,	Richard Lewis,	33.13	44.97	36.13	71.00	12.00	38.08	1	....	....	.	27.58	27.58	27.57
37	Bedford,	Bedford,	Samuel Brown,	39.45	52.45	43.57	76.20	18.00	45.16	.	....	....	.	29.00	29.02	29.05
38	Somerset,	Somerset,	George Mowry,	37.97	46.50	39.97	66.00	20.00	41.48	$\frac{2}{3}$	18.00	30.85	21	27.68	27.67	27.69
39	Indiana,	Indiana,	Richard White,	40.84	50.20	38.29	73.00	16.00	43.11	.	....	....	.	28.42	28.43	28.45
40	Jefferson,	Rose Cottage,	C. C. Gaskell,	31.31	46.22	33.92	70.00	9.00	37.15	$5\frac{1}{3}$	....	....	.	28.71	28.72	28.67
41	Warren,	Warren,	R. Brown,	34.18	47.56	33.76	68.00	11.50	38.50	$1\frac{2}{3}$	....	....	.	28.60	28.64	28.63
42	Venango,	Franklin,	Wm. Connelly,	31.74	48.84	38.74	75.00	14.00	39.74	.	....	....	.	....	28.76	....
43	Armstrong,															
44	Westmoreland,															
45	Fayette,															
46	Green,															
47	Washington,	Cannonsburg,	Jno. H. Kennedy.	39.23	51.52	41.35	77.00	18.00	44.03	.	....	....	.	28.87	28.86	28.87
48	Allegheny,															
49	Beaver,															
50	Butler,	Butler,	Jacob Mechling,	34.29	46.53	39.10	75.00	15.00	39.97	.	....	....	.	28.71	28.68	28.70
51	Mercer,	West Greenville,	John Keck,													
52	Crawford,	Meadville,	J. Limber,	38.71	44.74	39.74	68.00	24.00	41.06	.	22.00	34.84	.	28.53	28.53	28.54
53	Erie,	Erie,	Park & Reid,	35.68	41.50	35.55	62.50	20.00	37.58	.	15.00	29.37	.	29.28	29.28	29.28

Register.			Barometer.							Weather.												
Lowest.	Mean.	Days omitted.	7, A. M.	2, P. M.	9, P. M.	Maximum.	Minimum.	Mean.	Days omitted.	Clear.	Cloudy.	Days omitted.	Rain.	Snow.	Rain and Snow.	Thunder Showers.	Rain in inches.	North.	N. N. E.	N. E.	E. N. E.
.00	32.68	.	29.86	29.81	29.85	30.33	29.37	29.84	.	10⅔	19	1⅓	....	....	....	..	3.301	.	.	4⅓	.
....	....	.	....	....	....	....	....	....	.	.	.	.	....	....	....	..	.....	3⅕	.	4	.
....	....	.	29.36	29.34	29.35	29.80	29.00	29.33	6	6	17	8	....	....	....	..	.....	2⅖	.	1	.
.00	26.77	.	27.75	27.77	27.77	28.15	27.40	27.76	.	14⅓	16⅔	.	4	....	1	..	2.400	2⅕	.	⅗	.
.00	36.58	.	29.40	29.35	29.37	29.86	28.80	29.37	10⅓	5	10⅓	15⅔	....	....	....	..	2.128	2	⅖	2⅕	...
.00	36.26	2	29.31	29.27	29.34	29.83	28.81	29.31	4	13	14	4	6	3	....	1	2.795	2	.	2	...
.00	33.00	.	29.27	29.23	29.31	29.97	28.76	29.27	.	8⅓	22⅔	.	6	5	3	1	6.481	5	.	.	.
....	....	.	29.34	29.30	29.32	29.93	28.80	29.32	2⅓	10⅔	16	4⅓	....	....	....	..	2.600	.	.	2⅔	.
.00	34.10	.	29.18	29.19	29.18	29.69	28.63	29.19	.	11⅔	19⅓	.	...	5	....	3	2.117	2⅕	⅕	1⅔	.
.00	36.00	.	29.26	29.22	29.26	29.71	28.72	29.24	.	15⅕	15⅔	.	....	....	....	..	2.524	3⅕	.	2	.
.00	41.10	15	29.16	29.13	29.17	29.65	28.64	29.15	.	.	.	.	....	....	....	..	.....	.	.	.	.
.00	30.10	2	29.08	29.04	29.15	29.60	28.57	29.09	2	10	19	2	4	2	3	1	4.175	1⅗	.	1	.
.00	26.61	.	28.02	27.90	27.96	28.32	27.38	27.96	.	9	21⅔	⅕	6	3	2	2	5.073	1	.	.	.
....	....	.	27.58	27.58	27.57	28.03	27.00	27.58	1⅕	8	20⅔	2⅕	4	4	....	2	....	1⅔	.	⅕	.
....	....	.	29.00	29.02	29.05	29.92	28.08	29.02	.	15⅓	15⅔	.	5	3	....	1	.....	.	.	.	.
.00	30.85	21	27.68	27.67	27.69	28.07	27.16	27.68	⅔	8	22⅓	⅔	7	6	....	1	1.857	⅔	.	⅓	.
....	....	.	28.42	28.43	28.45	28.90	27.90	28.43	.	13	16⅔	1⅓	....	....	....	..	.....	.	.	.	.
....	....	.	28.71	28.72	28.67	29.80	28.30	28.70	6⅔	10⅓	13⅔	7	....	....	....	..	4.286	.	.	.	.
....	....	.	28.60	28.64	28.63	29.10	28.15	28.62	1⅔	10⅓	18⅔	2	....	....	...	..	.....	3⅔	.	⅓	.
....	....	.	....	28.76	....	29.28	28.10	....	20⅔	4⅓	6	20⅔	....	....	....	..	.....	.	.	.	.
....	....	.	28.87	28.86	28.87	29.35	28.25	28.87	.	10	21	.	....	....	....	..	3.598	.	.	3	.
....	....	.	28.71	28.68	28.70	29.10	28.20	28.70	.	12	19	.	2	4	1	2	3.189	.	.	1⅓	.
.00	34.84	.	28.53	28.53	28.54	28.95	27.87	28.53	.	8⅔	22⅓	.	9	5	1	2	4.641	2	.	⅔	.
.00	29.37	.	29.28	29.28	29.28	29.75	28.60	29.28	.	10⅓	19⅔	1	....	....	....	..	3.780	1	⅔	4	⅔

Winds.																	Hygrometer.					
North.	N. N. E.	N. E.	E. N. E.	East.	E. S. E.	S. E.	S. S. E.	South.	S. S. W.	S. W.	W. S. W.	West.	W. N. W.	N. W.	N. N. W.	Calm.	Days omitted.	Dew-point.	Days omitted.	Diff. therm. and dew point.	Wet Bulb.	Days omitted.	No. of Report.
.	.	4 1/3	1/3	.	.	.	1/3	.	1/3	11 2/3	2	.	1/3	11 1/3	.	1/3	.	....	.	.....	....	.	1018
3 1/3	.	4	.	3	.	4 2/3	.	1	.	5 2/3	1/3	5	1	3	.	.	.	....	.	.....	....	.	1015
2 1/3	.	1	.	7	.	.	.	1/3	.	3 1/3	2	7	.	2 1/3	.	.	5 2/3	....	.	.....	....	.	1004
2 1/3	.	2/3	.	1	.	4 2/3	.	2	.	3 2/3	.	3	.	7	.	6 2/3	.	....	.	.....	....	.	1216
2	2/3	2 1/3	1/3	1	1/3	2/3	.	2 1/3	1 1/3	3 1/3	1	3 1/3	1 1/3	7	.	2	1 2/3	39.95	9	.....	....	.	1008
2	.	2	2/3	1 1/3	.	1	1 2/3	2/3	3 1/3	1	2 1/3	3	2 1/3	3	2 1/3	.	4 1/3	38.01	13	.....	47.67	13	999
.	.	.	.	2	.	1 1/3	1/3	9 1/3	.	1/3	.	2 2/3	.	6 1/3	.	3 2/3	.	....	.	.....	48.62	1	996
.	.	2 2/3	.	1 1/3	.	2 2/3	.	.	.	2 2/3	.	2 1/3	.	9	.	8 1/3	2	....	.	.....	....	.	997
1/3	1 2/3	.	1 2/3	.	2 1/3	.	1 2/3	.	3	2/3	5	1 2/3	5	.	5 2/3	.	....	.	.....	....	.	1012
.	2	.	.	.	.	.	6	1 2/3	2	1	5	1	3 1/3	2/3	5	.	....	.	.....	....	.	1014
.	.	.	10	.	.	.	.	.	.	.	21	.	.	.	.	.	....	.	.....	....	.	1042
.	1	.	1/3	.	3 1/3	1/3	1 2/3	.	8	.	2 2/3	.	10	.	.	2	....	.	.....	....	.	1090
.	.	.	3 1/3	.	1	.	2/3	.	7	.	2 1/3	.	12	.	1/3	3 1/3	....	.	.....	46.12	7	1023
.	1/3	.	1/3	.	1 1/3	.	2	.	4	.	11	1/3	5 1/3	.	3 1/3	1 1/3	....	.	.....	....	.	1002
.	.	.	.	.	.	6	1/3	5 2/3	1 2/3	3 1/3	2 1/3	5 2/3	3 1/3	1 1/3	.	.	....	.	.. .	....	.	998
.	1/3	.	1/3	.	2	.	1	.	6	3 1/3	3 1/3	2 2/3	3 2/3	1/3	7 2/3	2/3	....	.	.....	....	.	1044
.	.	.	1	.	2/3	.	1 2/3	.	5 1/3	.	8 1/3	.	3 2/3	.	10	.	....	.	...	....	.	1057
.	.	.	.	.	1/3	.	.	.	4	1/3	.	1	3 1/3	.	15 1/3	6 2/3	....	.	... .	....	.	1017
.	1/3	.	1/3	.	.	.	1 1/3	.	.	.	7 1/3	.	1/3	.	16	1 2/3	....	.	....	....	.	1009
.	.	.	.	.	2	.	.	.	2 1/3	.	.	.	6	.	.	20 2/3	....	.	.....	....	.	1003
.	3	.	.	.	2	.	.	.	11	.	2	.	13	.	.	.	....	.	.....	....		1047
.	1 2/3	.	7 2/3	.	1	.	.	.	8	.	9 2/3	.	3	.	.	.	....	.	.....	....	.	1001
.	2/3	.	.	.	2 1/3	2/3	2/3	.	3	2/3	3 1/3	2	5 1/3	1	.	9	....	.	.....	....	.	1000
2/3	4	2/3	1	.	2/3	1	2	1	1 2/3	1 2/3	6 1/3	2 2/3	2	1 1/3	3 2/3	.	....	.	.....	....	.	1010